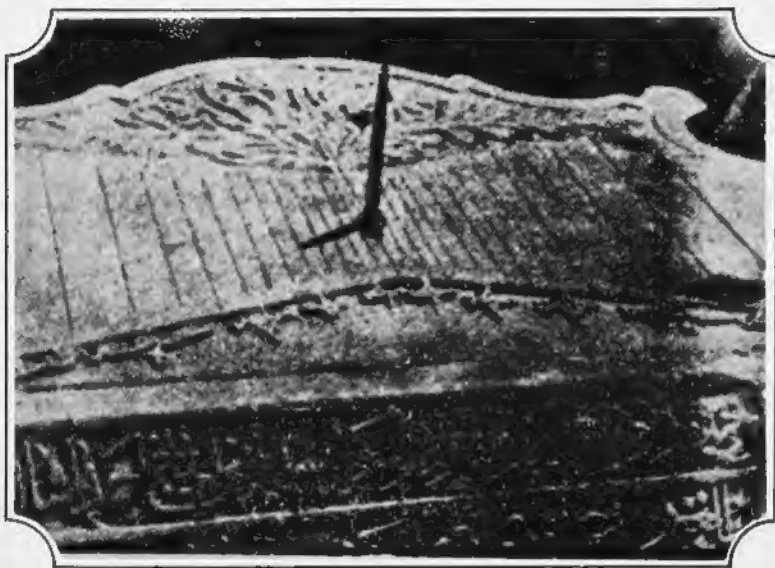


مجلة تاريخ العلوم العربية



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معهد التراث العلمي العربي
جامعة حلب - سورية



مجلة تاريخ العمل والعلاقات العربية

تشرين الثاني ١٩٧٨

المجلد الثاني

المجلد الثاني

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تصدر مجلة تاريخ العلوم العربية عن معهد التراث العلمي العربي مرتين كل عام
(في فصلي الربيع والخريف) - يرجى ارسال تسخين من كل بحث أو مقال الى :
معهد التراث العلمي العربي - جامعة حلب .

توجه كافة المراسلات الخاصة بالاشتراكات والاعلانات والأمور الادارية الى العنوان
نفسه - يرسل المبلغ المطلوب من خارج سورية بالدولارات الاميركية بموجب شيكات باسم
الجمعية السورية لتاريخ العلوم
قيمة الاشتراك السنوي :

المجلد الاول أو الثاني (١٩٧٧ ، ١٩٧٨)

٢٥	ليرة سورية أو ٦ دولارات أميركية	بالبريد العادي المسجل :
٤٢	ليرة سورية أو ١٠ دولارات أميركية	بالبريد الجوي المسجل :

المجلد الثالث (١٩٧٩)

١٠	دولارات أميركية	بالبريد العادي المسجل : كافة البلدان
١٢	دولارات أميركية	بالبريد الجوي المسجل : البلاد العربية والاوروبية
١٥	دولارات أميركية	آسيا وأفريقيا
١٧	دولارات أميركية	الولايات المتحدة ، كندا وأستراليا

مقالة في التطرق بالطب إلى السعادة لعلي بن رضوان

تحقيق

سلمان قطايش

نقدم ولأول مرة النص الكامل لمخطوطة « مقالة في التطرق بالطب إلى السعادة »
لعلي بن رضوان . وهو النص الوحيد المحفوظ حتى اليوم في مكتبة حكيم علي أوغلو
بإسطنبول الرقم ٦٩١ (٣) - ف ٨٩٤ .

ولقد تفضل معهد المخطوطات العربية بالقاهرة مشكورا ، فأمدتنا بصورة عنها .
والمقالة هذه على قصرها تتمتع ببعض الأهمية .

فهي : أولاً تساعدنا على تحديد زمن ولادة علي بن رضوان ، وبالتالي عمره ، فالعلوم
أن تحديد سنة ولادة العلماء المتقدم عسير عادة .

وقد ورد في كتاب « عيون الأنباء » لابن أبي أصيبعة^(١) عن ابن رضوان بُدِّ
من سيرته الذاتية يقول فيها : « . . . وكان يفضل عليّ إلى وقتي هذا ، وهو آخر السنة
التاسعة والخمسين . » ويقصد التاسعة والخمسين من عمره .

كما ذكر ماكس مايرهوف^(٢) ، خلال سرده القائمة الكاملة لمؤلفات ابن رضوان .
أن ثمة ثلاثة مؤلفات ربما كانت كلها واحدة أو متشابهة وهي :

« كلية الطب - جامعة حلب .

١ - ابن أبي أصيبعة - عيون الأنباء في طبقات الأطباء - طبعة بيروت - ١٩٦٥ - ص : ٥٦١ .

2 - M. Meyerhof, *The Medico-Philosophical Controversy between Ibn Buzlan of Baghdad and Ibn Ridwan of Cairo*, Egyptian University - Faculty of Arts Publication No. 18, (Cairo 1937) pp. 41-49.

- سيرته المذكورة في كتاب عيون الأنباء .
- ومقالة في التطرق بالطب الى السعادة .
- ومقالة في سبيل السعادة ، وهي السيرة التي اختارها لنفسه .

فاذا عدنا الى مقالة في التطرق ، رأينا ابن رضوان يقول « . . . وجدنا تاريخ الاسكندر الى وقتنا هذا هو سنة ست وثلاثين واربع مائة للهجرة . . . » .

فاذا اعتبرنا هذا التاريخ (اي عام ٤٣٦ هـ / ١٠٤٤ م) هو العام الذي بلغ فيه ابن رضوان سن الستين . استطعنا القول أنه ولد عام ٣٧٦ هـ / ٩٨٦ م ، وتوفي عام ٤٥٣ هـ / ١٠٦١ م (حسب ابن أبي اصيبعة) أو ٤٦٠ هـ / ١٠٦٧ م (حسب القفطي) ، وأنه عاش بين الخمس وسبعين عاماً والواحد والثمانين .

ونجد في المقالة نفسها معلومات تلقي بعض الضوء على مفهوم ابن رضوان عن التعليم الطبي الذي اهتم به كثيراً وذكره في معظم مؤلفاته . بل كرس له كتاباً بعنوان « النافع في كيفية تعليم صناعة الطب » (٣) .

ولا بد أن منشأ هذا الاهتمام هو ممارسته للتعليم والتدريس في بیمارستانات مصر . والمعلوم أن ابن رضوان اشتهر بقوله بأنه يمكن تعلّم الطب بدون استاذ (كما فعل هو نفسه اذ لم يُعرف له شيخاً تتلمذ على يديه) ، وانه انتقد كثيراً بسبب ذلك (٤) .

ففي كتاب « النافع » يدعي بأن التعلّم عن الكتب لوحدها ممكن انما ضمن شروط خاصة فيقول « وهذه الطريق يقوم لمن لا يجد معلماً جيداً مقام المعلم الجيد » كذلك فهو ليس بمقلود الا « ذوي القرائح الجيدة والطبائع الفائقة » .

وفي مقالة « التطرق » يعود فيؤكد هذه الفكرة فيقول « وليس يخلو المتعلم لها (أي صناعة الطب) من أمرين :

٣ - توجد نسختان : واحدة في دار الكتب المصرية بالقاهرة رقم : طب ٤٨٣ ، والثانية في مكتبة تليتر يبي في دبلن (رقم : ٤٠٢٦) .
٤ - ابن أبي اصيبعة - البيهقي - بيروت - ١٩٦٥ ص ٥٦٣ - ٥٦٣ .

١ - اما أن يجد معلما فاضلا يفهم منه ما في كتب ابقراط فيسرع بذلك تعلمه كما أسرع تعليم جالينوس .

٢ - واما أن يُعَدِّم المعلم الحاذق فيحتاج أن يتعلم لنفسه من كتب جالينوس فيطول زمان تعليمه .

ثم يشير الى أن القسم العملي من الطب لا يتم تعليمه الا : « بمعاينة هذه الاعمال بين يدي أفضل من تعلم عليه من اهلها » .

وهنا تبدو لنا أهمية مقالة « التطرق » لانها تقدم تفاصيل جديدة غير معروفة عنه ، وتجعل فكرته عن التعليم الطبي مقبولة الى حد ما . رغم اعتقادنا الجازم بأنه لا بد من معلم لكل من قسمي الطب : النظري والعمل .

ثم يكرس ابن رضوان الباب الثالث من المقالة لموضوع عنوان المقالة ، فيشرح مفهومه الفلسفي عن مهنة الطب .

وهو مفهوم مثالي مطلق فيقول « قال جالينوس في آخر المقالة الاولى من حيلة البرء : ويتبني لنا أن ننافس ونباهي الملائكة في فعل الخير » .

والفكرة هذه مشروحة بشكل مفصل في كتابه « في شرف الطب » . وهو مفهوم ديني مرتكز على أن الطب هو فعل الخير وواسطة لارضاء الله والقوز بالجنان ، ويعترف انه رغم ذلك فان الطب في ايامه (كما في كل زمان وعصر) لم يكن يخلو من الدجل والشعوذة .

ويبدو لنا أنه من الضروري التمييز بين من يختار مهنة الطب عن إيمان ديني عميق لا يريد منه سوى كسب مرضاة الله وهم الندرة . والغالبية التي لا ترى في الطب الا وسيلة لكسب المال والحياة الرغيدة . وهذا ما لم يره ابن رضوان ، أو آراء ولم يعترف به .

وينتقل ابن رضوان في مقالة « التطرق » الى تاريخ الطب قبل الاسلام . ونراه

لا يقدر أو يحترم الا ابقراط وجالينوس (*) . وخاصة هذا الأخير . إذ يعتبر كتبه فوق كل نقد ، أو شك ، بل ينتقد بقسوة كل من يتعرض لنقده (كالرازي مثلاً) .
وتلك نقطة ضعف في مؤلفاته ، لأن الفكر العلمي يبحث دوماً عن الحقيقة .
وهو في سبيل ذلك لا يتوانى عن مناقشة كل رأي بفكر علمي موضوعي .

٥ - شرح ابن رضوان مئة كتب جالينوس هي . كتاب الصناعة الصغيرة - كتاب الاطفاآت - كتاب البهس الصغير - بعض كتاب المزاج - كتاب جالينوس الى الخلقين - في التأني لشفاء الامراض - (ابن ابي أصيبعة - الحيوة - ص : ٥٦٦) .

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

مقالة علي بن رضوان في التطرق بالطب الى السعادة وهي ثلاثة ابواب .

الباب الاول - في كتب ابقراط .

الباب الثاني - في تعريف ابقراط .

الباب الثالث - في التطرق بالطب الى السعادة .

الباب الاول

في كتب ابقراط

قال علي بن رضوان : قد بينا في كتابنا^(١) ان ابقراط استكمل تعليم صناعة الطب وان جالينوس هذب تعليم ابقراط ، فصير صناعة الطب ميسرة سهلة التناول على من زاولها من ذوي الطباع العايقة ، واما عبر هاؤلاي فقد نهى ابقراط وحالينوس معاً عن تعليم هاؤلاي متى انتحلوها فهم فيها اطباء بالاسم لا اطباء بالفعل ، لتقصير طائعهم عن ادراكها . ولذلك هم السب في ذمتها . واوضحنا انه ينبغي ان يكون المتعلم لها طبيعة مواتية ، ودهن ذكي ، وحفظ جيد ، وحرص شديد ، واحتمال للتعب ، وحب للجميل .

وان يكون قبل تعلمها قد تأدت بالآداب والتعاليم فقد ذكر حالينوس^(٢) في مقالته في ترتيب قراءة كتبه . انه شرع في تعليم الطب بعد رياضة في التعاليم والآداب ، وقد بلغ في السن السنة السابعة عشر .

٦ - ربما كان يقصد كتاب . " الباع في كعبة تعلم صناعة الطب " بشكل حصص وهو مخطوط عبر مطبوع .

٧ Galien ولد حوالي عام ١٣٠ م في برغامس في ميسيا وتوفي حوالي سنة ٢٠٠ م ويُدعى العصر انه توفي عام ٢١٨ م . وهو من اكبر ائمة اليونان . وكتبه السنة عشر اشهر من ان تذكر .

وقال في غير هذه المقالة انه وضع كتابا في الاسطقات ، وهو ابن تسعة عشر سنة . وما كان يصنع ذلك الا بعد استكمال تعليم صناعة الطب ، وذلك انه عرف في تفسيره كتاب طبعة الانسان ليقراط . وضعه بعد ان وقف على آراء ابقراط ، وفهم ما في كتبه بقراءته اياها على حدائق المعلمين ، فحصل رمان تعلمه الطب ثلاث سنين فلذلك ينبغي (أن) يقتدى به في تعليم هذه الصناعة ، فيتأدب أولا في الاداب . ويرتاض في التعاليم ، ثم يقرأ كتب ابقراط . ويفهم معانيها . لم يكن احدا قبله هذا تهديبه .

١٥

فالحاصل من ذلك انه يمكن تعليم صناعة الطب في ثلاث سنين . وقد اشترط ابقراط في تعميمها شروطاً منها ما ذكرته أولا من حال طبعة للتعليم ، ومنها ان يكون حديث السن ، وهو من كان عمره ما بين سن البلوغ وبين خمس وعشرين سنة ، لان المراج على هذا السن اعدل منه في سائر الاسان . وقوى النفس تابعه مزاج البدن .

٢٠

وليس يخلو المتعلم لها من احد امرين :

- اما ان يجد معلما فاضلا يفهم منه ما في كتب ابقراط فيسرع بذلك تعليمه كما اسرع تعليم جالينوس .

- واما ان يعدم المعلم الحادق فيحتاج ان يتعلم لنفسه من كتب جالينوس فيطول زمان تعليمه متى استعمل في تعليمه قوانين المطلق .

ولأن صناعة الطب صناعة فاعلة لم يمكن تعليمها خُلُوّاً من منازل اعمالها الجزئية . كما بين ذلك ارسطوطاليس فيما بعد الطبيعة . ان كل صناعة فاعلة انما تحصل وتكمل بمعرفة قوانينها الكلية ، وبمنازلة اعمالها الجزئية .

٢٥

فادن . المتعلم لصناعة الطب ، مع قراءته كتب ابقراط ، يزمه ضرورة ان ينازل بنفسه اعمالها الجزئية وذلك يتم بمعاينة هذه الاعمال الجزئية بين يدي افضل من تعلم عليه من اهلها . وقد وضع جالينوس لكتبه التي هذب فيها تعليم بقرراط ولخصه هيرست (٨) ولقرايتها ترتيب . فالمتعلم يأخذ ذلك من جالينوس . واما كتب بقرراط

٨ - كتب عن الحاشي فكنت ال ديفتي بحير من سعد في ذلك مجدتي مه مهرستها

فلم يقع لي فيما سلف لها فهرست. ذكر انه ترجمه من اليوناني الى العربي. فقرأته فوجدت الكتب غير مرتبة ، ولم يتفق حصول جمعها عندي فأرتب قراءتها. وذلك انه يعوزني منها نحو اثنا عشر مقالة فرأيت ان أنسخ لي في هذا الموضع ما وصل الي من فهرستها على ١ ط هيته . وهذا هو :

- كتاب التاموس مقاله (٩)
- كتاب الوصية مقالة
- كتاب العهد مقالة
- كتاب الفصول سبع مقالات
- كتاب مقدمة المعرفة ثلاث مقالات
- كتاب قاطيطريون ثلاث مقالات
- كتاب مقدمة الانذار مقالتان
- كتاب مقدمة الانذار المنسوب الى اهل قسو
- كتاب الامراض ثلاث مقالات
- كتاب تدبير الامراض الحادة و هو كتاب ماء الشعير ثلاث مقالات
- كتاب الغذاء اربع مقالات
- كتاب التدبير ثلاث مقالات
- كتاب استعمال الرطوبات
- كتاب الادوية
- كتاب الحقن
- كتاب ابيديميا سبع مقالات
- كتاب الاعظم في العلل
- كتاب العلل الباطنة

٩ - لقد نسب الى امبراط كتب كثيرة ويقول ابن ابي اصيبعة (العيون ص ٥٣) " والذي انتهى اليها ذكره ووجدنا في كتب امبراط الصحيحة يكون نحو ثلاثين كتابا والذي يدرس من كتبه لمن يقرأ صناعة الطب اذا كان دوسه على اصل صحيح وترتيب جيد ، اثنا عشر كتابا وهي المشهورة من كتبه " ولقد وضعت اشارة الى جانب كل كتاب من هذه الكتب الاثني عشر ، ورد ذكره في قائمة علي بن رضوان

- كتاب المرض الكاهني
 كتاب الاساييع مقالة
 كتاب النفخ مقالة
 " كتاب الالهوية والبلدان والمياه اربع مقالات
 كتاب الطب القديم
 كتاب الصناعة
 كتاب البصر
 * كتاب الاختلاط ثلاث مقالات
 كتاب الورم
 كتاب الجراحات القاتلة
 كتاب خراجات الرأس
 كتاب انتراع البثور (١٠)
 كتاب البواسير
 كتاب النواصير
 كتاب الكسر والرض
 كتاب المفاصل
 كتاب نهايات الامراض
 * كتاب طبعة الجنين ثلاث مقالات
 * كتاب طبعة الانسان ثلاث مقالات
 كتاب المواضع التي في الانسان
 كتاب المولودين لسعة اشهر
 كتاب المولودين لثمانية اشهر
 كتاب المولودين لتسعة اشهر
 كتاب حبلى على حبلى
 * كتاب الكسر (١١)

١٠

١٠ - في الاصل البثور

١١ - في الاصل: الكسر . وفي قائمة ابن ابي اصيبه ورد اسم "كتاب الكسر والجبر . ويقول هذا (العمرون - -
 ص ٥٥) " ولا يقرأ ايضا من الكتب ويضعها مشمول اليه . . "

كتاب تقطيع الجنين الميت
 كتاب في الامراض
 كتاب نبات الاسنان
 كتاب العذارى
 كتاب تدبير النساء
 كتاب من يبول الدم
 كتاب علل النساء
 كتاب النساء اللواتي لا يحبلن
 كتاب الجبر
 كتاب الساج
 كتاب البدع
 كتاب اعتقاد اهل اثينا
 فذلك خمس وخمسون كتاباً .

قال علي : وليس هي مرتبة . ويمكن ان ترتب ترتيباً : احدهما يليق باصحاب التجارب (١٢) وهي ان يبدأ بقراءة قاطيطرون ، وتفسيره حانوت الطبيب ، ثم نذني بعده كتاب الكسر والرض ، ثم كتاب الحر ، ثم كتاب الخراجات . ثم سائر الكتب العلمية على ترتيب ما ينبغي ان يقرأ شيئاً بعد شيء .

فاذا فرغت الكتب العلمية ، يبدأ بعدها بكتاب طبيعة الانسان وترتيب القراءة فيها على ما ينبغي .

والترتيب الاخر يليق برأى اصحاب القياس : وهو ان يبدأ بقراءة كتاب طبيعة الانسان ثم يوالي القراءة على ما ذكرت ويحفظ طاهر كتاب الفصول ، وكتاب مقدمة المعرفة فاذا فرغت كتب علم هذه الصناعة يبدى بقراءة كتاب قاطيطرون وما بعده على حسب ما يوجه العمل .

١٢ - Empiriques . والمعلوم انه كان ثمة ثلاث مدارس طبية يورثه

اصحاب القياس Dogmatistes - الذين يعتمدون على الملاحظة والمنطق

واصحاب الخيل Methodistes الذين يعتمدون على مقداره الارض بنية طريقة كاد اشعائه وامهم

طائفة Thessalus واصحاب التجارب الذين كانوا يعتمدون على نتائج تجربته العملية العلاجية

الباب الثاني

في تعريف ابيسقراط (١٣)

ويقال ان معنى هذا الاسم : ماسك الفرس .

قلوا : انه اتفق لرجل كان شديد القوة انه ضرب يده الواحدة الى رأس او
 عنق فرس هابح ، وضرب يده الاخرى الى اصل دونه ، فمسكه قائما لا يقدر يتحرك .
 فتعجب الناس من شدته وسموه بقراطيس اي ماسك الفرس واشتهر هذا الاسم في
 اليونانيين ، فحضر به المثل لكل من كان من الناس شديد القوة ، الى ان صار اليونانيون
 يسمون اناسهم كما نحن نسمي اناسنا اسد وصاعد نحو ذلك الى يومنا هذا .

٢٥

والمشهور هذا الاسم من علماء اليونانيين خمسة رجال . احدهم ذكره
 ارسطوطاليس (١٤) في المقالة الاولى من السماع الطبيعي ، وفي غيرها اعاد ذكره على انه رجل
 مهندس ظل انه وحد مربع الدائرة . فان هذه المسألة تختلف فيها الى يومنا هذا بين المهندسين .
 والاربعة الباقون اطباء ذكرهم جالينوس في تفسير كتب ابقراط فقال في مقالته في
 المولود لسبعة اشهر : لقد اختلف المفسرون لكتب الفاضل ابقراط . منهم من قال :
 ان جميع هذه الكتب وضعها ابقراط واحد ، ومنهم من قال : انها ليست لواحد .
 وذلك ان القوم الذين كانوا يسمون بهذا الاسم . اعني ابقراط ، اربعة نفر يتلو بعضهم
 بعضا واوهم : بقراط ابن اغنوسيديقس والثاني : بقراط بن ايراقليدس ، والثالث :
 بقراط بن باساكوس (١٥) ، والرابع : بقراط ابو دراقن وخميسهم كتب .

٣٠

وقال في تفسيره المقالة الثانية من كتاب طبيعة الانسان . بقراط الكبير له ولدان
 احدهما تاسالس (١٦) ، والاخر دراقن . ولكل منهما ولد سماه بقراط .

قال علي : وعرف جالينوس ذلك في مواضع آخر من كتبه . وقال : ان تاسالس
 بن بقراط كان من المتقدمين في صناعة الطب . لكنه لم يحلف اباه بقراط في التعليم بمدينته .

٥

١٣ - ويسى ايضا بقراط ويلقب بالكبير والحكيم والفاضل والاعلى واي الطب توفي حوالي عام ٣٥٧ ق . م

١٤ - يكتب ايضا ارسطوفيلسوف يوناني شهر (٢٨٤ - ٣٢٢ ق . م) .

١٥ - ليلها - تاسالوس ١٦ - في الاصل - تاسالوس

لكن صَحِيحَ ارسالاولس الملك والذي خلف بقراط في التعليم تلميذه فولوبس ، وذلك ان بقراط بن ايراقليدس كان له جماعة من التلاميذ وولده تاسايس (١٧) ودراقن ، ولم يخلفه في التعليم سوى تلميذ فولوبس ، وذكر ان المقالة الثالثة من كتاب طبيعة الانسان التي هي حفظ الصحة لفولوبس (١٨) ، وان المقالة الثانية من كتاب ابيذيما لتاسالس (١٩) وان قوما نسوا كتاب الملودين لثمانية اشهر الى فولوبس . وبالحملة فليس ما وضعه هاؤلاي الرجال السبعة الاربعة المسمون بقراط ، والثلاثة تاسالس (٢٠) ودراقن الى بقراط بن اراقليدس لان هو الذي خرج له الاسم وكان افضل القوم ، وافضل جميع من كان في عصره ، ومن تقدمه ومن تأخر الى يومنا هذا من الاطباء .

لهذا سمي بقراط الكبير وشاع اسمه في الدنيا في حياته ، وبعد وفاته الى ابد الابدن ، ما دام الناس موجودين . ولقد بلغ من امره في حياته ان ملك الفرس المسمى بملك الملوك ارطخششت (٢١) بذل (٢٢) له مائة قنطار ذهب ، والهبات العظيمة (٢٣) ، وحرائر فاخرة على ان يسير اليه ويتخذه بالطب مما فعل ولا اجابه . وبذل له اهل ابديرا (٢٤) عشر قناطير ذهب على علاج حكيمهم دمقراط (٢٥) لما طنوا انه يغير عقله ، فرد المال ومن عليهم وسار اليه معهم . فلما شاهد دمقراط علم انه صحيح ، وانه لما اشتغل بالعلم عن تدبير مدينتهم طنوا انه قد تغير عقله ، فاعلمهم بقراط انه صحيح وانه آثر الانفراد والحلوة بالطير والفلسفة والسكون عن تدبير المدينة . وانصرف عنهم الى مدينته قو . ولأنقراط اخار كثيرة ، وعجائب جدا ، تدل على فصيلة عظيمة ، وشرف عظيم . وانا اثبت وضع بقراط في العمورة ، ووضع مدن الحكماء المشهورين بالحكمة الصحيحة ، فان بطلميوس (٢٦) صحح وضع هذه المدائن في كتابه في صورة العمورة من الارض فمنها قو مدينة ابقراط : فطولها مد درجة ، وعرضها كسر درجة . واما قرغاس مدينة

١٧ - في الاصل - تاسايس

١٨ - في الاصل - فولوبس

١٩ - في الاصل - لتاسالس

٢٠ - في الاصل - تاسايس

٢١ - في الاصل - اد صحت والاعلى انه اردشير والاصل اردشير . وفي اليونان ان ابقراط كان ي

عهد "جس بن اردشير" ٢٢ - في الاصل - ابدل ٢٣ - في الاصل - حطية .

٢٤ - جزيرة يمانية صغيرة اشهر اهلها بخفة العقل .

٢٥ - اوديمقراطيس وهو فيلسوف تلميذ ارسطو وعاش في حدود عام ٤٥٩ ق . م .

٢٦ - ويسمى ايضا بطلساوس ويطليموس واطليموس ويطلموس (٢٨٥ - ٢٤٦ ق . م)

جالسوس . فطولها دله وعرضها مآر وأما اثينا مدينة الحكماء . وهي مدينة سقراط (٢٧) وافيلاطون (٢٨) : فطولها يب م وعرضها لذلك . فجميع هاؤلاي في الاقليم الرابع . وفي الصف العربي من المعمور قريب من متناه الى جهة المشرق امحاور لاشياء وذلك ان الحكمة نقلها من مصر نالس الملطي (٢٩) . وفيثاغورس (٣٠) الى اليونانيين . لانها سفروا الى مصر وتعلموا من حكمائها وسارا الى اليونانيين فاطهروا ما تعلموا من اهل مصر . لان مصر كانت في القديم دار الحكمة والعلم . وهذه الحكاية يشهد بصحتها كتاب التوراة . وقد كتبها فلاطون وارسطوطاليس في كتبهما . ودونها فرفوربوس وغيره ممن عي نكتب تواريخ الحكماء من الفلاسفة والاطباء . وذكر جاليسوس في كتبه ان الطب اقتصر عليه اسقليبيوس (٣١) . واسقليبيوس مختلف فيه فطائفة زعمت انه ملك بعثه الله عز وجل فعلم اهل هذا البحث صاعة الطب فسمي على عادة القدماء في تسمية المعلم اباً للمتعلم . وطائفة زعمت انه رجل اوحى اليه الطب واستخرج هو ايضا من تلقاء نفسه . واليه تكسب الاطباء في سالف الدهر . وذلك ان الطب كان اولاً بجزيرة رودس (٣٢) اخذها اهلها عن حكماء المصريين ثم انتقل الى اهل هذا البيت بجزيرة قنيدس (٣٣) . ثم انتقل الى جزيرة قو (٣٤) .

اما جزيرة رودس فطولها عر وعرضها لسو . واما جزيرة قبيلس فطولها لويه وعرضها لو . واما جزيرة قو فطولها ع مر وعرضها فيما سلف

وكان الطب في هذا البيت يتعلمه الولد من ابيه وجده فقط . ولا يمكن عريب تعليمه الى ان نشأ ابقراتون ايرقليدس المشهور بالفضيلة . فحات على الطب ان يبدي ويصدد . فشرط شروطا انت تقف عليها من كتاب التاموس والوصية والعهد على المعلم

٢٧ - اقراطيس فيلسوف يوناني حكم عليه الموت بالسم .

٢٨ - في الاصل - ملاحون . وهو الفيلسوف اليوناني المتأني (٤٩٧ - ٣٨٧ ق . م) .

٢٩ - بولس الانيطي او القوابلي - احد اطباء مدرسة الاسكندرية

٣٠ - Pythagore حكم يوناني . رار مصر وبابل واثام . ويعرى انه تقوم الحساب المعروف بمجدول

فيثاغورس في العرب توفي في حريرة - موس (حوالي عام ٢٠٠ ق . م)

٣١ - يسمى ايضا اسقليبيوس واسقليبياديس

٣٢ - Cos

٣٣ - Rhodes

٣٤ - Rodos

والمتعلم . فمن الزم نفسه تلك الشروط وكانت فيه ، اباحة التعليم ، كان من نسله او من غير نسله . وكان تلميذه هولوبس افضل تلاميذه ولم يرل الطب ينتقل من واحد الى واحد الى ان انتهائه الى جالينوس ، وليس هو من نسل اسقليبوس ، قريب جالينوس (٣٥) الاقاويل الفاسدة وبهرج الاراء الكاذبة الردية وهذب صناعة الطب هيمما وضعه من التفاسير لكتب ابقراط . ومن كتبه وعرف في تفاسير وكتب ابقراط الاقاويل المدلسه عليه التي دلستها الناس السوء على انها يسيرة جدا بالقياس الى ما في هذه الاراء الصحيحة التي اخفي فيها ذلك التدليس ، فاداك كان كذلك لا فائدة محددة في كتب غير بقراط وجالينوس سوى الكتب التي نص عليها مثل كتاب ديسقوريدس (٣٦) في الادوية المفردة ، ومسا سوى لا يتنفع به وضار لا محالة بالمتعلمين . اذ كان لا يمكن علاج مرض حتى يعرف اوقاته الكلية والجزئية فيعطى في كل واحد منها ما ينبغي ، وهذا لا يمكن الا ان يفهم كتاب الفصول ، وكتاب مقدمة المعرفة ، وكتاب البحران ، وحيلة البرء .

واذ قد ذكرنا مدائن الحكماء ، وانا نريد في تعريف بقراط بمعرفة تاريخه وثاربع كل واحد من الحكماء المشهورين بالفصيلة فاقول : ان جالينوس يقول في غير موضع من كتبه انه كان على عهد ادريانوس الملك وانه تخصص بخدمة انطونيس وهو الذي ملك بعد وفاة ادريانوس . وقد بلغني في ذلك حكاية حكاها في كتابه المعروف بالادوية (المقابلة) (٣٧) للأدواء نحو ثلثي المقالة الاولى بأن جالينوس اتى لما اتخذت الترياق لانطونيس الملك رأيت اواني عده مملوه دار صيني (٣٨) بعضها حزن على عهد طراباويوس وبعضها على عهد ادريانوس ، ورأيت جميع اصناف الدار صيني التي جذبتها واحد بفصل كل منها على صاحبه في القوة والضعف والطعم والرائحة بحسب تقادمه في الزمان الاول من

٣٥ - ستغرب مثل هذه الصفات ان ينسبها علي بن رضوان الى جالينوس . لان علي مثل الزادي والكثيرين من الاطباء العرب يصدون عن بقراط ولكم لا يقرأون ويستشهدون الا بكتب جالينوس . وقد فسر وشرح ابن رضوان ستة كتب لجالينوس . وخلال كل ما قرأناه من كتب ابن رضوان هذه تلميذا متحمسا جداً له .

٣٦ - ويسمى ايضا دياسقوريدوس ويلقب بصاحب النفس الزكية والسائح وحكيم الخشاشي والخبز رربي هاش في القرن الاول والثاني بعد الميلاد . وله كتاب الخشاش الشهير .

٣٧ - غير معهودة
٣٨ - Cinnamonum Zeylanicum وهو نبات يشه القره
(انظر احياء التذكرة - رمزي معتاح) - القاهرة ١٩٥٣ - ص ٢٩٢ - وكتاب بعمرات لابن البيطار (- بولاق - ص ٨٧) .

اصناف الدار صيني فالتخذت منه معجوناً لمرقس الملك المسمى انطونيس فوجدت ذلك المعجون افضل من سائر المعجونات ، حتى ان الملك لما داقه لم يدعه مدة من الزمان ، كما يفعل سائر المعاجين الى ان يستحكم (٣٩) . لكنه استعمله على المكان (٤٠) من غير ان تنزله شهرين . فلما ورث الملك بعد فورمودس الذي لم يكن لا بالترياق ولا بالدار صيني ، صاع ما كان معي من تلك الشجرة ، وكلما جلب من الدار صيني بعد اندرانوس حتى ان ملكا سورس امر ان يتخذ له الترياق على ما كان يتخذ لانطونيس ، فاضطرت ان اختار لعمله من الدار صيني . هبنت من ذلك الترياق بياناً واضحاً انه اضعف على انه ، لم يكن مضى على الدار صيني ثلثون سنة كاملة .

قال علي . وبطلميوس في كتاب المجسطي (٤١) انه رصد ثلاث كموفات قمرية باسكندرية في عقر ادريانوس الملك ويقول في المقالة الثالثة : ورصدنا نحن ٣ والاستواء الحريمي بعابة الاحتياط والتحرز من الخطأ في السنة الثالثة لانطونيس وهي سنة اربع مائة وثلاثة وستين من وفاة الاسكندر .

قال علي . فحالينوس إذاً معاصر بطلميوس . وعدت الى جداول سني الملوك فوجدت بين وفاة الاسكندر وبين اول ملك انطونيس الذي اسمه مرقس اربع مائة وستين سنة . وهذا تاريخ صحيح لا شبهة فيه ، وان ارسطوطاليس معاصر للاسكندر . وان فلاطس معلم ارسطوطاليس ، وان سقراط معلم فلاطس وجالينوس ، يقول بلفظه في آخر المقالة الاولى من تفسيره لكتاب طبيعة الانسان ، لما استشهد فلاطس الفيلسوف انه اخذ عن بقراط فان فلاطس : كان قريب العهد بتلامذة بقراط ، وفي جداول تاريخ الملوك ملك الفرس المعاصر لافلاطس كان المسمى ارسيس آخوس وبين هذا الملك وبين وفاة ارطخششت الذي كان معاصر بقراط مائة واربع سنين ، هبنا اذن ان سقراط لقي (تلميذ) (٤٢) بقراط سمافولوبوس وتعلم منه ، ولذلك التقى على فلاطس ما ذكره من كلام انقراط في طبيعة الانسان واستحسن طريقة ، فسلكتها في معرفة طبيعة النفس ، فاذا بين وفاة ارطخششت الذي كان بقراط معاصره ومن قبل الاسكندر له من السنين مائة

٤٠ - اي - فور .

٤٢ - في الاصل - تلاميذ .

٣٩ - اي - حتى يضيغ

٤١ - Almagest

واحدى وعشرون سنة الى ان توفي الاسكندر سنة ست عشر سنة ، فجمع ذلك مائة وسبعة وثلاثون سنة ، وادأ اضيف اليه ما بين رصد بطلميوس وبين وفاة الاسكندر كان ما بين بقرط وجالينوس من السنين خمس مائة وسبعة وثلاثون سنة . وادأ قابلنا ما استخرجنا من هذا الحساب ما ذكره يحيى الحوي في تاريخه وتفسيره كان للادوية المقابلة للادواء ، وجدنا يحيى النحوي^(٤٣) يقول . مس رمى وفاة بقرط الى ظهور جالينوس ستمائة وخمسة وستون سنة وان بقرط عاش خمسة وسبعين سنة ، وجالينوس عاش سبعة وثمانون سنة منها صبيا ومتعلما سبع عشر سنة ، وعالما ومعلما سبعون سنة .

قال علي : فالخلف اذن بين التاريخين سبعة وسبعون سنة فان كان انقراط توفي في عصر ارطخست اربعة وعشرون سنة ولذلك ان كان ما ذكره يحيى هو الذي علمناه جالينوس صح قوله وان لم يكن كذلك فقد عرض له سهو في التاريخ اصح وواقع ، لانا اخذناه من قبل بطلميوس ويجلول تاريخ الملوك وليس في ذلك شبهة ولا شك وهو ان بين جالينوس ، وبين بقرط ستمائة سنة فقط ، وادأ حسنا ما بيننا وبين كل واحد منهما وجدنا تاريخ الاسكندر الى وقتنا هذا ، وهو سنة ست وثلاثين واربعة للهجرة ، الف وثلاثمائة واثنين وستين سنة تامة زدنا عليها مائة وسبعة وعشرين سنة بين وفاة ارطخست وبين وفاة الاسكندر فيكون ما بيننا وبين انقراط الف واربعمائة وتسعة وثمانون سنة ، وادأ نقصنا من تاريخ الاسكندر الاربعماية والثلاث والستين سنة ، كان بيننا وبين جالينوس تسع مائة سنة بعشرات سنين واحاد لان جالينوس يقول في كتابه في فهرست كتبه ان اقليدس اشخصه معه من بلده اليه وقد جاوز سبعة وثلاثون سنة بمقدار قليل قد يمكن تصحيحه فقد تبين مما ذكرت ان منه هاؤلاي الحكماء .

فلنعود الان الى غرضنا في هذه المقالة وهو ان نبين كيفية التطرق بالطب الى السعادة .

٤٣ - Jean le Grammaire - احد علماء مدرسة الاسكندرية ، عاصر الفتح العربي . وهو احد الذين شاركوا في الفناء ووضع الكتب الستة شرح جالينوس .

الباب الثالث

في التطرق بالطب الى السعادة

قال علي : قد بينا فيما سبب ان صاعدا الطب يمكن ان تتعلم في ثلاث سنين .
وانه لا حاجة بالطبيب الى عبر كتب قنراط وجالينوس وكتب دياسقوريدس ولذلك
اقول ان التشاغل بغير هذه الكتب كما قال بعض الناس دار حمى للاشتياق المحرومين
المكبلين الذين لهم الى الخير المحض سبيل فيعدوه وقد تبين ان الطبيب يمكنه ان يفعل
الخير ويصطبغ المعروف الى الناس في حعط صحة ابدانهم وشفاء امر صهم حتى
يقوموا الى اشغالهم .

وقد قال جالينوس في آخر المقالة الاولى من حيلة الشراء : ويبغي لنا ان ننافس
وندهي الملائكة في فعل الخير فانه لا شيء اقبح ولا اشنع من ان يقدر على فعل الخير
فيتوانا عنه ويطرحة وحكا عن اوديسوس في مقالة في تعرف لانسان عيوب نفسه .
يا لك من مر من اقبحه وازدراه ان تعرف الخير ولا تعمل به . وقال ارسطوطاليس
ليس التواي عن العناية بالخير شر وكان الاسكندر يقول : مما احبته عن معلني
ارسطوطاليس اني لا اعد ملكي يوما لم افعل فيه خيرا ولم احسن فيه الى انسان . وظاهر
ان الطبيب الماهر اذا قصد الاحسان الى الناس فلا بد ان يحصل له منهم ما يكفيه في الضرورة
وزيادة عليه .

قال قنراط : انه ليس في الدنيا شيء يمي باحرة الطبيب اذا كانت الصحة لا
عيش الا بها ، ولا يتم شيء من الاعمال الا بها . والخلاص من المرض انما هو الخلاص
من الموت ، فذلك لا يفي شيء وان كثر ناجرة الطبيب ، لكن اجره على الله عز وجل .
وما حصل له فيسفي ان يكون على وجه الهدية والصلة ، فاما غير ذلك وادا كان يمكنك
فمن اين ان الطبيب يتوصل الى الكفاية في الضرورى . والى الاحسان الى الناس وفعل
الخير . ولما اجتمع قنراط مع دمقراط في ابديرا المدينة فضحك دمقراط ضحكا افرط فيه
فسأله قنراط عن السبب المضحك له فقال دمقراط بهذا اللفظ : اخرجني يا بقراط الى
اصحك طول تعجب مما ارى عليه امور الناس واحوالهم التي انا اشرحها لك لانهم

يفتون اعمارهم فيما لا يعود عليهم بمففعة زمانهم مما يجب ان يهتروا به ويضحت منه فمهم من يجول اقطار الارض ويتعب نفسه ويشقيها وبذلها حرصاً على اقتناء الذهب والفضة فاذا حصل له مات وتركها ، ولم ينتفع منها شي . ومهم من يشتري الخيل والدواب والضياع والارضين الواسعة ويعمرها ويغرس فيها الاشجار ويجعلها ملكاً خاصاً له وهو لا يقدر يملك نفسه ، ما هذا الخرص القارع الذي لا فرق بينه وبين الكينون ، اذا افادوا المال راد واشترى الارصين واذا اشروها باعوا علائها وثمارها وجمعوا مطا . فكم في السرة يتقبلون ، اذا لم يكن لهم ثروة تأسفوا واغتموا ، واذا اثروا استروا ما لهم وعطوه . وخافوا وقوع الحيلة عليهم فيه . قد شقيت نجوتهم ، ونخطوا بواميس الحق لمحبتهم لمعاملة فبعضهم يعادي بعضا ، وعيهم من يقاتل احواله واولاد بيته ، وبني مدينته بسب اغراض الدنيا التي اذا مات نزلها ولم يكن مالكا لها . فلم اغزل يا بقراط على صحيكي الا ترى ان الاسكارى اذا اختلطت عقولهم . صحتك عليهم . والعشاق تضحك منهم وليس بهم من المرحس اكثر مما وصعاه . فالرؤساء يقولون الخط والسعادة للعامة . والعامة تشتهي الرياسة والمدر للمدينة ان الصانع بايديه اسعد واحمد عاقبة . والصناع يعطون المدير للمدينة .

قال ابقراط . قلت الحق يا دمقراط واقسم بالله انك لسعيد لما رحمت من هذا السلوان (٤٤) .

قال علي : وقد بين ارسطوطاليس ان السعادة هي الحياة بالعقل وان العمر الطيب (٤٥) اللذيذ هو العمر مع العقل ، اد ليس احد يختار الحياة وعقله عقل صبي . ومن عقول الصبيان التماس الشهوات البهيمية وبين ايضا فيما بعد الطبيعة ان التمتع بالشهوات ودلوع الاماني منها اما هي ادراكات ملدة . ومن كان حظه من هذه الادراكات و
الملدة اكثر ، كان مغبوطا بما له اكثر ولذلك يكون ان من كان اكثر ادراكا للامور العظيمة ، فهو اوفر سعادة واكثر حظا ولذلك صار الحيوان افضل من النبات وذلك انه اكثر ادراكا من قبل انه حيوان حكيم له يدان يبطش بهما وعقل يفكر فيه ويتروى ويتعلم ، ويستعمل الكلام ، والمخاطبات ، ويجد اصناف الاطعمة اللذيذة . والنبات

الرفيعة والنعم الحسنة ، والالوان المتنوعة (٤٦) . ويلتد بما يشاهد من رؤية السماء بالكواكب ورؤية الارض بالمياه والانهار . ومطبوع على حب الرياضة وتتوق نفسه الى معرفة اسباب ما يشاهد من الاشياء ومكمل بما ادرك من ذلك . ويتوق غيره بحسب ما يعصل عليه في الادراك ويصير افضل منه ، وهو ممن عرف عنايته الى الريادة في الفهم والمعرفة ، وان كان افضل ممن لم يتزايد بظن ان حظه من امور الدنيا اقل من حظ غيره من على (. . .) (٤٧) بها وذلك لثلاثة اوجه احدها ان فضائل الا بادخار (٤٨) جيد للابناء والثاني البحث الحادث عس عطايا النجوم في المواليذ ، والثالث ان يعرض لمن انصرف الى النظر في اللذة تا يدركه من كسر النفس ، ما يشعله عن الاكتساب . والخفوع الى من هو دونه في الفهم . وحل هذا الشك سهل لانه لا يقوته وجود الصرورى والحظوظ مراد للادراكات اللبيدة . ولا شيء من الادراكات اللبيدة ولا اجل ولا افضل من ادراكات النظر الفلسفي ، وكلما كان ادراك الانسان افضل واسعد على الحقيقة . وافضل الادراكات ووافقها يقينا وصحة هي الادراكات الفلسفية اعني النظر في الحكمة واستعمال العدل والسحاء والمعة في نفقات المال . هاذن : السعادة الاسابية على اليقين والصحة هي التفلسف عينا وعملا ولقد رأينا من على ذلك الطبيب اذا انصرف بعض يومه في رياضة بدنه في اعمال الطب وصرت ما في يومه في العمل الصالح والفكر في ملكوت السماوات والارض ، وعبد الله واطاع العقل وذلك ما اردنا بيانه .

تمت مقالة علي بن رصوان في التطرق بالطب الى السعادة . والحمد لله وصلى الله على سيدنا محمد واله اجمعين . نقلت ذلك جميعه من نسخة دقيقة الخط الى عية ما يكون ما يعرف منه اول الحرف من اخر الا يفتح من الله سبحانه وتعالى ، بعبارات غريبة بعيدة عن القصد واتخير في اختصارها او اصلاحها ، ولطف الله جل وعلا بحسب ما امكن من القدرة . وارجو من كرم الله تصحيحها ان شاء الله تعالى وهو حسينا ونعم الوكيل . نقل عبيد الله سلمان ابن الاسعد المتطبب عفا الله عنهما . في شهور سنة نور عشر وثمان مائة (٤٩) ، احسن الله عاقبتها .

ملخصات للبحوث المنشورة في الملتقى العلمي

مسألة هندسية وحسابية
لشرف الدين الطوسي

رشدي راشد

لقد بينا في دراسات سابقة أهمية أعمال شرف الدين الطوسي الرياضية ، وهذه الأعمال هي :

١ - كتابه « في المعادلات » الذي يمثل خطوة أساسية في تاريخ الجبر ونجد فيه بنور ما سيمى من بعد بالهندسة التحليلية .

٢ - رسالته « في الخططين اللذين يقربان ولا يلتقيان » ، وهذه الرسالة هي أحد أشكال الكتاب السابق ومن ثم لا يمكن اعتبارها كعمل منفصل .

٣ - جواب على سؤال سألته أمير المدرسة النظامية بعداد ، وهذه الرسالة هي موضوع مقالنا هذا وهي آخر عمل رياضي نعرفه لشرف الدين الطوسي وموضوعها :
قسمة مربع معلوم إلى مستطيل وثلاثة محرفات على نسبة معلومة .

فمن البين إذاً أن هذه الرسالة تهدف إلى بناء شكل هندسي يحقق علاقات عديدة معينة بالمسطرة والرجل ، واتباع الطوسي فيها طريق التركيب مخافة التطويل ، ولكن هذا الطريق وحده لا يفسر لنا اختيار الطوسي للقيم العددية المتعددة ولا للأبنية التي يقوم بها لتسلسل عرض تلك الأبنية . فلذا رجعنا إلى مفاهيم الطوسي ووسائله كما نعرفها من

كتابه « في المعدلات » لأدراك وتحديد التحليل المستمر وراء التركيب بنزما افتراض ترجمتين : الأولى ترجمة جبرية للمسألة الهندسية تنتهي إلى معادلة جبرية ، الثانية ترجمة هندسية للمسألة الجبرية هدفها الرد على السؤال المروص بالنساء الهندسي . وهاتان الترجمتان تعبران عن علاقات جديدة بين الجبر والمهلمسة وعن تصور مختلف للمشكلة التقليدية أعني مشكلة التحليل والتركيب منذ كتاب عمر الخيام في الجبر والمقابلة ورسائله في قسمة ربع دائرة على شروط مفروضة . ومن الجدير بالملاحظة أن الجبريين لا يهتمون الوصول إلى نتائج حسابية محددة . كما يشهد بذلك رسالة الخيام ورسالة الطوسي التي نحن بصدددها .

فأهمية مسألة طوسي تعود إلى طريقة الحل وعما تعبر عنه من تصور للعلاقات التي ذكرناها ولا ترجع إلى صعوبة المسألة ولا إلى ندرة هذا النوع من المسائل . فمن المعروف أن هذا النوع لم يكن أدرأقل الخيام والطوسي من بعده بل قد توصل الرياضيون إلى حلول مسائل أكثر صعوبة أي تلك التي لا يمكن عملها بالمسطرة والرجل كتحكيم زاوية إلى ثلاثة أقسام متساوية وغيرها من المسائل الهندسية التي تستلزم قطوع المخروطات .



ملاحظات حول كتاب المفروضات لأقاطن

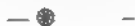
دولدم سامبولونيوس

لقد عالجت المؤلفة رسالة المفروضات لأقاطن بالتفصيل في أطروحتها للدكتوراه (أمستردام - ١٩٧٧) . وهي موحودة في نسختين تعودان للقرن الثالث عشر . أحدهما والتي تحمل عنوان كتاب المفروضات لأقاطن موحودة في مخطوطة أيا صوفيا رقم ٤٨٣٠,٥ في استنبول (٨٩ ط - ١٠٢ ط) . وتتألف من ٤٣ فرضية في الهندسة المستوية . وهناك ١٩ فرضية من الصف الأول تشكل رسالة منفصلة تحت عنوان كتاب أرشميدس في الأصول الهندسية . وهي موجودة في مخطوطة بانكيبور رقم ٢٤٦٨,٢٩ (١٤١ و - ١٤٤ ط) . وقد نشر مكتب المشورات الشرقية العثمانية (حيدر أباد - دكن ١٩٤٧) نسخة عربية لهذه المخطوطة مع مخطوطة بانكيبور رقم ٢٤٦٨,٢٨ (١٣٤ ط - ١٤١ و

كتاب أرشميدس في الدوائر المتماثلة) وقد تم ذكر أسباب قبول عنوان كتاب المفروصات وأقاطن مؤلفاً له في الفصل الثاني من الأطروحة .

وقد أضيف لعنوان مخطوطة بانكيبور ما يلي - « ترجم ثالت بن قررة الرسالة من اللغة اليونانية إلى اللغة العربية » . وسنعمد على الحدس والتوقع في معرفة العنوان اليوناني الأصلي للرسالة والأسم الذي كان يُطلق على أقاطن في اليونانية. إن فعل حرص ربما يقابل في اليونانية فعل (ὑποτίθω) أو بمعنى خاص يمكن أن يقابل (συγχωρεῖν) وعلى هذا الأساس فإن كلمة مفروصات هي ترجمة لكلمة (συγχωρεσεις) أو كما في الحالة السابقة (ὑπόθεσεις) . وليس للمؤلف علم بوجود أية إشارة إلى رسالة يونانية تحمل أتباً من العناوين . وفي حالة اسم المؤلف فقد أقرح الفارسية (مهوية) كواسطة بين الاسم اليوناني والاسم العربي . وبهذا يمكن الوصول إلى الاسم اليوناني الأكثر شيوعاً (Δαγών) . ولكنه لم يتم ذكر أي رياضي هذا الاسم .

وتتضمن الرسالة (الأطروحة - الفصل الثالث) فرضيات جديدة بالاهتمام ، لكن دون وجود نظريات ذات شأن كبير . وتعالج بعض الفرضيات الخواص الأساسية للمثلثات وبعضها يدخل في نطاق علم المثلثات والأخرى تتصل بعلم البصريات . ومن خلال دراسة العلاقة بين رسالتنا ومجموعات ببوس فإنه ربما كان أقاطن أحد معاصري ببوس . ويمكن ملاحظة تأثيرات مختلفة على الرسالة (الأطروحة - الفصل الرابع) . والمكان الوحيد الذي له علاقة مباشرة بالفرضيات العربية هو في رسالة ابن الهيثم « في خواص المثلث من جهة العمود » . وفيها يبرهن ابن الهيثم على تقابل ارضيات ٨ - ١٠ « إن مجموع الأعمدة في مثلث متساوي الأضلاع مرسوم من نقطة داخلية إلى الأضلاع الثلاثة بساوي ارتفاع المثلث » . فهو يبرهن على ذلك أولاً في حالة مثلث متساوي الساقين وثانياً في حالة مثلث متساوي الأضلاع . وعلى أية حال إن هذا التعميم ليس صحيحاً ولا زالت رسالة أقاطن تحتفظ بقيمتها وأهميتها بالنسبة لعلماء الرياضيات العرب في القرن الثالث عشر كما هو واضح من الملاحظات الهامشية العديدة .



كناش في الطب العربي من القرون الوسطى : كتاب المئة لأبي سهل المسيحي

غادة الكرمي

أُلِّفَت في اللغة العربية كتب طبية شاملة وعديدة بعد عام ٢٠٠ للهجرة . وكانت هذه الكتب تعرف باسم « كُنَاشَات » . ويشير هذا الاسم إلى نوع معين من الكتب الطبية التي كانت تتضمن جميع المعلومات الاساسية بشكل مختصر حول الممارسات والنظريات الطبية في ذلك الوقت . وكلمة « كُنَاش » ليست عربية بل هي مشتقة من الكلمة السريانية « كُنَاشَه » وتعني مجموعة . وأصبح « الكُنَاش » على مر الزمن أكثر الكتب انتشاراً التي كان يستخدمها الطبيب وطال الطب على حد سواء

ان « كتاب المئة » لأبي سهل المسيحي كُنَاش نموذجي يعود للقرن الرابع . والمسيحي طبيب عاش في بلاد الفرس وقد قيل إنه أحد معلمي ابن سينا . توفي أبو سهل حوالي ٤٠١ - ١٠١٠ . وقد ألف كتباً عديدة في الطب والمنطق والفلسفة . ولكن أشهر كتبه هو « كتاب المئة » . ولا يزال هذا الكتاب موحوداً فيما لا يقل عن ٢٩ مخطوطة تم نسخها في فترة امتدت منذ القرن الخامس حتى أواخر القرن الماضي . وكان كُنَاش المسيحي يتمتع بقيمة عظيمة أيام طهوره وفيما بعد . ولكنه لم يترجم أبداً إلى اللغة اللاتينية في العصور الوسطى كما حدث لمؤلفات طبية عربية كثيرة .

يقدم هذا البحث نبذة عن حياة أبي سهل المسيحي ووصفاً لمحتويات كُنَاشَه وتورد المؤلفه مقتطفات من النص العربي مع ترجمة انكليزية لها . ولم يتم تحقيق هذا الكتاب حتى الآن . ومادة البحث مستفدة من مخطوطات لهذا الكتاب . وتعرض المؤلفه لمكانة وأهمية هذا الكُنَاش وتبحث في الاسباب التي أدت الى عدم ترجمة هذا الكتاب الى اللغة اللاتينية خلال القرون الوسطى .

تقرير عن مخطوطة هامة للجزري

دونالد هيل

يصف هذا البحث مخطوطة رائعة من كتاب الجزري في الآلات . وقد نشر المؤلف ترجمة انكليزية لهذا الكتاب وستصدر قريباً نسخة عربية قام بتحقيقها الدكتور أحمد يوسف الحسن (معهد التراث العلمي العربي - حلب) . وكان يُعتقد سابقاً أن هذه المخطوطة قد تشتت كلها ، بالرغم من أنه قد تم الإشارة إلى وجود عدد من الأشكال في مجموعات عامة وخاصة . على أن ٧٠ ٪ من المخطوطة الكاملة قد عرض للبيع من قبل شركة سوثبيز في لندن في الرابع من نيسان ١٩٧٨ واشترتها شركة سينك في لندن أيضاً لقاء أكثر من ١٦٠.٠٠٠ جنيه استرليني . ويعبر المؤلف عن امتنانه هاتين الشركتين لتعاونهما معه ولترويده بصور فوتوغرافية ولسماحهما بنشر هذا البحث .

لقد كتبت المخطوطة على ورق مصقول سيك . قياس كل صفحة ٢١٩ × ٣١٤ مم . مخط نسخي جميل جداً . وتحتوي كل صفحة ٢١ سطراً . ويشير حرد المن (الكولوفون) الموجود في الصفحة الأخيرة إلى اسم الناسخ (فرح بن عبد اللطيف) وإلى تاريخ هذه النسخة (١٣١٥ هـ / ١٧١٥ م) . ويعتقد أنه قد تم اعداد هذه النسخة إما في سورية أو في مصر . وتأتي هذه النسخة في المرتبة الثالثة من حيث قدمها . وهي أجملها بالرغم من أنها ناقصة .

ويقدم البحث على شكل جداول تحليلية كاملاً للمحتويات المتبقية من المخطوطة بمقارنتها مع المحتويات الكاملة المعروفة سابقاً من مخطوطات أخرى . ومن الأبواب الخمسين الأصلية هناك ١٤ باباً كاملاً مع الأشكال . ويوجد الآن ١٠٦ أشكال صغيرة ورسوماً توضيحية من أصل ١٧٣ . ويوجد منها ١٩٦ شكلاً رئيسياً . وقد تم نشر سبعة أشكال ملونة من المخطوطة في البحث المنشور في قسم الأبحاث الأجنبية من هذا العدد . وهي تتضمن فوارتين ورأس حوارة وآلة موسيقية آلية وثلاثة أشكال للمضخة المكبسية (ذات الاسطوانتين المتقابلتين) والمعروفة جداً للباحثين .

علم الفلك الاسلامي في اللغة السنسكريتية

دافيد بنجمري

يقوم هذا البحث بدراسة انتشار علم الفلك الاسلامي في الهند عبر قرون عديدة ويدرس أيضاً ردود الأفعال المختلفة للعلماء الهود تجاه الطرق والنتائج التي مارسها زملاؤهم المسلمين . ويركز البحث بشكل خاص على قضية فشل هذا النقل في احداث تغيير هام في علم الفلك الهندي . ويرى المؤلف أن حلاً جزئياً لتلك القضية يكمن في عدم تفهم الهود لمنهجية علم الفلك عند المسلمين .



الساعة الشمسية التي وجدت

في جامع ابن طولون في القاهرة

دافيد كينج ولويس جنان

إن آثار الساعة الشمسية الرائعة التي كانت قبل كسرها ترين جامع ابن طولون في القاهرة منذ سنة ٦٩٦ هجرية وتعيد زوار الجامع بالوقت الماضي من شروق الشمس والباقي إلى غروبها كما وكانت تين لهم وقت ابتداء صلاة الظهر والعصر قد اختفت أثناء البحوث التي احرثت عليها على أيدي المستشرقين الفرنسيين المتتبعين إلى بعثة نابليون في أوائل القرن التاسع عشر . ولحسن الحظ لم تختف الساعة إلا بعد أن رسمها أحد أعضاء البعثة رسماً دقيقاً . وقد بحث المؤلفان في هذا الرسم من حديد لكي يخللا الخطوط المحتفة التي توجد على وجه الساعة كما بحثا في الجداول التي استخدمها الفلكيون في العصر المموكي ليخططوا ساعات من هذا النوع .



ثلاث ساعات شمسية من الأندلس

دافيد كينج

توجد في متاحف إسبانيا ثلاث ساعات شمسية يرجع عهدها إلى العصر الإسلامي في الأندلس . وقد بحث المؤلف في رسومها المختلفة التي ترتبط بالساعات الزمانية من النهار وبوقتي صلاة الظهر والعصر . ومع أن إحدى هذه الساعات من صناعة أحد الفدكيين المشهورين من الأندلس في أواخر القرن الرابع الهجري إلا أنه يوجد في تخطيطها بعض الأخطاء . أما الساعتان الأخريان فصناعتهم تقريبية وقد حاول المؤلف أن يكشف طريقة رسمهما ويظهر من البحث أن صناعة الساعات الشمسية في الأندلس لم تكن على مستوى صاعتهما في الشرق الإسلامي كما أمكننا تصويره من الرسائل المؤلفة في موضوع تخطيط الساعات في العصر العباسي .

المشاركين في العدد

عادل أنبوا : يبحث في تاريخ الجبر والهندسة - درّس تاريخ العلوم عند العرب والرياضيات في الجامعة اللبنانية وفي الكلية الفرنسية للعلوم الاقتصادية في بيروت . تضم منشوراته دراسات عن الكرجي والشجاع بن أسلم والسموءل وآخرين من علماء الرياضيات العرب .

داليد بنجري : أستاذ في قسم تاريخ الرياضيات بجامعة براون . يتقن استخدام المصادر السنسكريتية والعربية واللاتينية واليونانية . وله اهتمام خاص في تاريخ علم التنجيم .

جاري في : محاضر في جامعة أوكلاهو ، بورلندا ، قسم الرياضيات . يعمل بشكل أسامي في التحليل العددي والحساب بالإضافة إلى تاريخ العلوم

لويس جنان : دكتور في الحقوق . تقاعد من عمله في بولك عدد من الدول العربية . وهذا ما جعله يهتم بتاريخ العلوم عند العرب وبشكل خاص في نظرية الساعات الشمسية في العصرين الوسيط والحديث

سامي حمارة : باحث في المتحف القومي للتاريخ والتكنولوجيا . مهتم سميثونيان ، واشطن . مؤرخ في الطب والصيدلة عند العرب . له كتب ومقالات عديدة في هذا المجال منها : « أصل الصيدلة والعلاج في الشرق الأدنى » و « ابن النفط الطبيب والمعالج والحراح » .

ايون دولد - ساميلونيوس : تدرّس حالياً تاريخ الرياضيات عند العرب في جامعة هيدلبرغ ها منشورات في تاريخ الهندسة عند العرب . وتعمل الآن في كتاب المقروصات لثابت بن قرة .

وشدي راشد : أستاذ بتاريخ العلوم في المركز القومي الفرنسي للبحوث الفرنسية للعلوم ومعهد تاريخ العلوم بجامعة باريس . تخصص منشوراته دراسات في تاريخ الجبر والهندسة

سلمان قطايه : أستاذ أمراض الأذن والأنف والحنجرة في كلية الطب بجامعة حلب . له مؤلفات وأبحاث عدة في تاريخ الطب .

غادة الكرعي : طبيبة ومؤرخة في الطب العربي . تقوم الآن لدراسات وأبحاث في تاريخ الطب عند العرب في معهد التراث العلمي العربي بجامعة حلب .

ادوارد س. كتهدي . استاد سابق في الجامعة الامريكية في بيروت واستاد باحث حالياً في معهد التراث العلمي العربي بحلب. له ابحاث وكتب عديدة في تاريخ الفلك والرياضيات عند العرب والمسلمين.

دالميد كينج . يعنى بشكل أساسي في علم الفلك والرياضيات عند المسلمين في العصر الوسيط . يعمل الآن في مركز البحوث الأمريكي بالقاهرة . له مشورات عديدة في علم الميقات .

دونالد هيل يزاول عمله كهندس . ويبحث في تاريخ التكنولوجيا العربية . ترجم كتاب الخزري الى الانكليزية ويقوم حالياً باكمال تحقيق مخطوطات بي مومي

ملاحظات لمن يرغب الكتابة في المجلة

- ١ - تقديم بحثين من كل بحث أو مقال الى معهد التراث العلمي العربي . طبع النص على الآلة الكاتبة مع ترك فراغ مزدوج بين الاسطر وهوامش كبيرة لأنه يمكن أن تجرى بعض التصحيحات على النص ، ومن أجل توجيه تعليمات الى عمال المطبعة . والرجاء ارسال ملخص يتراوح بين ٣٠٠ - ٧٠٠ كلمة باللغة الانكليزية إذا كان ذلك ممكناً وإلا باللغة العربية .
- ٢ - طبع الحواشي المتعلقة بتصنيف المؤلفات بشكل معصل وتبعاً للأرقام المشار إليها في النص مع ترك فراغ مزدوج أيضاً . وكتابة الحاشية بالتفصيل ودون أدنى اختصار .
- أ - بالنسبة للمكتب يجب أن تحتوي الحاشية على اسم المؤلف والعنوان الكامل للمكتب والناشر والمكان والتاريخ ورقم الجزء وأرقام الصفحات التي تم الاقتباس منها .
- ب - أما بالنسبة للمجلات فيجب ذكر اسم المؤلف وعنوان المقالة بين أقواس صغيرة واسم المجلة ورقم المجلد والسنة والصفحات المقترن منها .
- ج - أما إذا أشير الى الكتاب أو المحلة مرة ثانية بعد الاقتباس الأول فيجب ذكر اسم المؤلف واختصار لعنوان الكتاب أو عنوان المقالة بالاضافة الى أرقام الصفحات.

أمثلة :

- أ - المطهر بن طاهر المقدسي ، كتاب البدء والتاريخ ، نشر كلمات هوار . باريس ١٩٠٣ ، ج ٣ ، ص ١١ .
- ب - عادل انبوبا ، « قضية هندسية ومهندسون في القرن الرابع الهجري » ، تسبيح الدائرة ، « مجلة تاريخ العلوم العربية . مجلد ١ ، العدد الثاني : ١٩٧٧ ص ٧٣ .
- ج - المقدسي ، كتاب البدء والتاريخ ، ص ١١١ .
- انبوبا ، « قضية هندسية » ، ص ٧٤ .

— منشورات معهد التراث العلمي العربي —

صدر حديثاً النص العربي الكامل لكتاب الجزري

الجامع بين العلم والعمل النافع في صناعة الخيل

تعقيق الدكتور أحمد يوسف الحسن

هذا الكتاب مرجع لا غنى عنه لمؤرخي التكنولوجيا والعلوم . إنه النص العربي الكامل الذي يتجاوز ٥٠٠ صفحة والذي تم تحقيقه بالرجوع الى أفضل مخطوطات الكتاب المعروفة في الوقت الحاضر . وقد تم اعداد ورسم ١٧٥ رسماً بعد دراسة دقيقة وشكل مطابق للرسوم الاصلية . ويبحث الكتاب في مختلف انواع الآلات الميكانيكية والهيدروليكية العربية التي تميز الابداع العربي في مجال الهندسة الميكانيكية في القرن الثاني عشر / الثالث عشر الميلادي ويحتوي الكتاب على فهرس شامل للمصطلحات الفنية مع معجم للمصطلحات بالانكليزية والعربية . مما يصفي على الكتاب قيمة كبيرة .

تحت رعاية السيد رئيس الجمهورية
الندوة العالمية الثانية لتاريخ العلوم عند العرب

٥ - ١٢ نيسان ١٩٧٩

التسجيل طوال ٤ نيسان

حلقات البحث :

- ١ - تاريخ الجبر العربي
- ٢ - مكانة الثقافة العلمية في الحضارة الإسلامية
- ٣ - انتقال العلم العربي الى الغرب اللاتيني

الجلسات العلمية :

- الطب
- الزراعة والحيوان
- فلسفة العلوم وانعائها
- العلوم الدقيقة (رياضيات - فلك - تنجيم - فزياء)
- الكون - الكيمياء - المغناطيسية - علوم الارض
- التكنولوجيا
- أبحاث عامة في تاريخ العلوم العربية

★ ★ ★

وجه المراسلات الى :

الآنسة أمل رفاعي - مكتب الرئيس - جامعة حلب

حلب - الجمهورية العربية السورية

مطبوعات معهد التراث العلمي العربي بجامعة حلب

أ - الكتب :

- ١ - أحمد يوسف الحسن : فني الدين والهندسة الميكانيكية العربية مع كتاب الطرق السنية في الآلات الروحانية من القرن السادس عشر ١٩٧٦ •
٨ دولارات
- ٢ - جلال شوقي : رياضيات بهاء الدين العاملي ٩٥٢ - ١٠٣١ هـ / ١٥٤٧ - ١٦٢٢ م - ١٩٧٦ •
٨ دولارات
- ٣ - سلمان قطاية : معطولات الطب والصيدلة في المكتبات العامة بحلب ١٩٧٦ •
١٠ دولارات
- ٤ - إدوارد كندي وعماد هانم : ابن الشاطر فلكي عربي من القرن الثامن لهجري / الرابع الميلادي - ١٩٧٦ •
٦ دولارات
- ٥ - إدوارد س • كندي : أفراد المقال في أمر الظلال للبروسي •
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- ٦ - معهد التراث العلمي العربي : أبحاث الدوة العالمية الاولى لتاريخ العلوم عند العرب (المنقذة بجامعة حلب من ٥ - ١٢ نيسان ١٩٧٦)
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ب - الدوريات :

- ١ - مجلة تاريخ العلوم العربية : دورية علمية متخصصة تصدر مرتين كل عام • المجلد الاول (١٩٧٧) • المجلد الثاني (١٩٧٨)
الاشتراك السنوي ٦ دولارات •
- ٢ - هاديات حلب : حولية تبحث في تاريخ الحضارة والآثار والعلوم : المجلد الاول (١٩٧٥)
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٦ دولارات للعدد الواحد •
- ٣ - رسالة معهد التراث العلمي العربي : نشرة دورية تصدر أربع مرات كل عام • الاشتراك السنوي ٤ دولارات بالبريد العادي ، ٥ دولارات بالبريد الجوي •

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Institute for the History of Arabic Science

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Abū Bakr Muḥammad b. Zakariya al-Rāzī, (fl. 251/865 - 313/925)

Dr. Salman Katayé has edited this text from the three known copies of the manuscript. It is a unique document in its manner of exposition and diagnosis of illnesses through questions and answers.

This edition contains an introduction, diagrams supplementary to the text, indices and a table of contents. The indices include a glossary of technical terms, both ancient and modern.

350 pages, 7 illustrations.

Forthcoming PUBLICATIONS

- Pseudo-Apollonius of Tyana (*Bālīnūs*), *Sirr al-Khalīqa*, Arabic text edited by Ursula Weisser.
- ‘Umar al-Khayyām, *Al-Jabr w'al-muqābala*, Arabic text edited by Roshdi Rashed.

Publications of the Institute for the History of Arabic Science

- Al-Hasan, Ahmad Y.,** *Taqi al-Din and Arabic Mechanical Engineering, with the Sublime Methods of Spiritual Machines. An Arabic Manuscript of the 16th Century.*
In Arabic. 165 pp. 1976. \$ 8.00
- Kataye, Salman,** *Les Manuscrits Medicaux et Pharmaceutiques dans les Bibliothèques Publiques d'Alep.*
In Arabic. 440 pp. 1976. \$ 10.00
- Shawqi, Jalal, S. A.,** *Mathematical Works of Bahā' al-Din al-ʿĀmilī.*
(953-1031/1547-1622). In Arabic. 207 pp. 1976.
\$ 8.00
- Kennedy, E. S., Ghanem L. (Eds.),** *The Life and Work of Ibn al-Shāfir-an Arab Astronomer of the 14th Century.*
In Arabic and English. 172 pp. 1976. \$ 6.00
- Kennedy, E. S.,** *The Exhaustive Treatise on Shadows by Abū al-Rayhān Muḥammad b. Ahmad al-Bīrūnī,*
In English. 281 pp, 221 pp. 1976
Vol. I Translation
Vol. II Commentary \$ 25/set
- ʿAdiyāt Ḥalab.** An annual on archaeology, history of art and science.
In Arabic and English. Vol. I (1975) pp. 368, Vol. II (1976)
pp. 354, Vol. III 284 in Arabic, 56 pp. French and English
summaries (1977) Each Vol. \$ 6.00
- Proceedings of the First International Symposium for the History of Arabic Science (ISHAS), held 5-12 April 1976, Aleppo.**
Vol. I in Arabic. 970 pp. \$ 25.00
Vol. II in other languages.
- Proceedings of the Second (1977) Conference of the Syrian Society for the History of Science.** In press.
- Journal for the History of Arabic Science.** An international journal. Vol. I (1977) Spring and Fall. Vol. II (1978) per volume \$ 600.
- I.H.A.S. Newsletter,** a quarterly, 1978.

To Contributors of Articles for Publication in the Journal for the History of Arabic Science

1. Submit the manuscript in duplicate to the Institute for the History of Arabic Science. The text should be typewritten, double-spaced, allowing ample margins for possible corrections and instructions to the printer. Please include a 300-700 word abstract in Arabic, if possible, otherwise an abstract in the language of the paper.

2. Bibliographical footnotes should be typed separately according to numbers inserted in the text. They should be double-spaced as well, and contain an unabbreviated complete citation. For books this includes author, full title (underlined), publisher, place, date, and page numbers. For journals give author, title of the article enclosed in quotation marks, journal title (underlined), volume number, year, pages. After the first quotation, if the reference is repeated, then the abbreviation *op. cit.* may be used, together with the author's name and an abbreviated form of the title.

Examples :

O. Neugebauer, *A History of Ancient Mathematical Astronomy* (Springer, New York, 1976), p. 123.

Sevim Tekeli, "Taqī al-Din's Method of Finding the Solar Parameters", *Necaci Lugul Armaganı*, 24 (1968), 707-710.

3. In the transliteration of words written in the Arabic alphabet the following system is recommended:

ʾ, a, b, t, th, j, h, kh, d, db, r, z, s, sh,

ا ب ت ث ج ح د ذ ر ز س ش

ṣ, ḍ, ṭ, ẓ, ʿ, gh, f, q, k, l, m, n, h, w, y

ص ض ط ظ ع غ ف ق ك ل م ن ه و ي

For short vowels, a for *fatha*, i for *kasra*, and u for the *damma*.

For long vowels the following diacritical marks are drawn over the letters ā, ī, ū.

The diphthong aw is used for *ai* and ay for *ay*.

NOTES ON CONTRIBUTORS

Adel Aaboubi, works on the history of algebra and geometry. He has taught the history of Arabic science and mathematics at the Lebanese University and at the French Faculty of Economics in Beirut. His publications include studies on al-Karaji, Shujā' b. Aslam, al-Samaw'al, and other Islamic mathematicians.

Yvonne Dold-Samplonius, presently teaches the history of Arabic mathematics at the University of Heidelberg. She has published studies on the history of Arabic geometry and is currently working on Thābit b. Qurra's *Kuṣb al-mafrūdā*.

Sami K. Hamarneh, of the Smithsonian Institution's National Museum of History and Technology, is a historian of Arabic medicine and pharmacy. He is the author of several books and articles on these subjects, including *Origins of Pharmacy and Therapy in the Near East*, and *The Physician, Therapist, and Surgeon, Ibn al-Quff*.

Donald Hill, is a practicing engineer whose avocation is the history of Arabic technology. He has published an English translation of the treatise of al-Jazari, and is currently completing an edition of manuscripts of the *Baḥā Mūsā*.

The editors have just learned with sadness of the sudden death of Louis Jamin, *docteur en droit*. He had retired some time ago from a banking career which included residence in various Arabic-speaking countries. This led to his interest in Arabic science, in particular medieval and modern geonometrics.

Ghada Karmi, is a physician and historian of Arabic medicine. She is engaged in research at the Institute for the History of Arabic Science.

Salman Kutaye, is Professor of Otorhynolaryngology at the Faculty of Medicine, University of Aleppo. He has published several works on the history of medicine.

E. S. Kennedy, sometime professor of mathematics at the American University of Beirut, is currently a research professor at the Institute for the History of Arabic Science. He has published several studies in the history of Arabic-Islamic science.

David A. King, whose professional interest is in the astronomy and mathematics of medieval Islam, is resident in Egypt. In particular, he has numerous publications in the field of astronomical timekeeping.

David Pingree, is a professor in the History of Mathematics Department at Brown University. He controls the Sanskrit, Arabic, Latin, and Greek sources, and has a special interest in the history of astrology.

Roshdi Rashed, is director of research at the C. N. R. S. Institute for the History of Science, University of Paris. His publications include studies in the history of algebra and geometry.

Garry J. Tee, is a senior lecturer in the mathematics department of the University of Auckland. He works chiefly in the fields of numerical analysis and computing, but also in the history of science.

Summary of the Arabic Article in This Issue

A propos du discours "Fi'l-tatarruq fi'l-ribb ilâ al-sa'âda" (Vers le bonheur par l'intermédiaire de la médecine de 'Alî b. Riḍwân)

SALMAN KATAYE

Nous présentons pour la première fois, le texte complet du manuscrit *Maqāla fi'l-tatarruq fi'l-ribb ilâ al-sa'âda* de 'Alî ibn Riḍwân. Ce texte, unique, est conservé jusqu'à présent dans la bibliothèque de Hakîm Uglû Bacha.

Ce discours revêt une certaine importance.

Il nous permet de déterminer la date de naissance de 'Alî ibn Riḍwân et de calculer son âge avec précision.

Nous pouvons relever dans ce même traité certaines évocations portant sur la conception qu'avait Ibn Riḍwân de l'enseignement médical. Il prétend qu'on peut étudier la médecine sans professeur. Ce qui lui a attiré beaucoup de critiques.

Dans *al-Tatarruq*, il expose de nouveaux arguments rendant son point de vue plus acceptable.

La troisième partie de son discours est consacrée au développement du titre de ce dernier, il explique alors l'aspect philosophique de la pratique médicale. C'est une conception religieuse qui s'appuie sur l'idée que la médecine est un acte de charité et un moyen de satisfaire Dieu et mériter le paradis.

Enfin, dans ce même discours, Ibn Riḍwân aborde l'histoire de la médecine pré-islamique. Nous remarquons qu'Hippocrate et Gaben sont, d'après lui, les seuls dignes d'être estimés et respectés, surtout Galien, dont les ouvrages sont, à son avis, d'une valeur incontestable, il s'en prend même durement à ceux qui l'ont critiqué, tel Rhazes.

science to mediaeval Europe. Although the two Dutch publishers are to be commended for publishing these two volumes, it might have been more appropriate for the entire text to have been published in the scholarly journal where it began to appear.

GARRY J. TEE

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H. L. L. Busard, *The Translation of the Elements of Euclid from the Arabic into Latin by Hermann of Carinthia (?)*, Books I-VI. Leiden, E. J. Brill, 1968. 142 pages.
(Books I-VI) 24 f.

H. L. L. Busard, *The Translation of the Elements of Euclid from the Arabic into Latin by Hermann of Carinthia (?)*, Books VII-XII. Amsterdam, Mathematisch Centrum, 1977. 198 pages Mathematical Centre Tracts 84

In 1271, Gerard d'Abbeville bequeathed to the Sorbonne a Latin manuscript, (Bibl. Nat. Latin 16646) of Euclid's *Elements*, Books 1 to 12, and that text has now been printed by Busard. Books 1 to 6 are contained in the 1968 volume (which is reprinted from *Janus*, 54, 1-2, (1967)), and Books 7 to 12 are contained in the 1977 volume - Books 7 to 9 had first been printed in *Janus* (59, (1972), 125-187). The manuscript does not contain Euclid's Book 13, on the regular polyhedra.

The Latin text is obviously translated from Arabic, and there is some tenuous evidence suggesting that the translator might have been Hermann of Carinthia (fl. 1143). Hermann is known mainly as the translator from Arabic into Latin of Ptolemy's *Planisphere* (which has survived solely through his translation), and as co-translator with Robertus Keteuensis of the *Koran*.

This Latin translation of Euclid appears to be intermediate in time between the 3 versions ascribed to Adelard of Bath (fl. 1116-1142), and the version ascribed to Campanus of Novara (c 1205-1296), which was used for the first printed edition of Euclid.

It is approximately contemporary with Gerard (c1114-1187) of Cremona's translation, which includes the pseudo-Euclidean Books 14 and 15. Campanus made use of the versions by Adelard, but Busard considers that this version by Hermann (?) was not used by Campanus.

Busard analyses and compares the several known Arabic and Latin texts of Euclid, in order to determine which Arabic version was used as the source of this text. In the 1968 volume, after an analysis of Books 1 to 6 he considers that it was translated from Thābit ibn Qurra's revision of the translation by Ishāq ibn Hunayn. However, in the 1977 volume, after analysing the full text, he considers it more likely to have been translated from the very first Arabic version of Euclid, the translation made by al-Ḥajjāj ibn Yūsuf ibn Maḥar under the patronage of Hārūn al-Rashīd.

This Latin text cannot have had much influence on the development of geometry, since no other manuscript of it is known, but it is of some interest for the evidence which it presents concerning the transmission of Arabic

from a manuscript (in Uppsala) in which the work is attributed to al-Fārābī (who died in 339/950). In fact, in a later book (A.K. Kubesov, *Matematicheskoye naslediyē al-Fārābī*, "The Mathematical Heritage of al-Fārābī", in Russian, Izd. "NAUKA" Kaz. SSR, Alma-Ata, 1974), Kubesov explains pp. 52-53) that the manuscripts of the work *On Geometrical Constructions* incorporate almost the entire book *On Geometrical Figures* (written by al-Fārābī, according to the Uppsala manuscript), together with some additional material, presumably supplied by Abū'l-Wafā'. On p. 29, Toomer mentions citations of al-Fārābī's commentary on Ptolemy's *Almagest*. "Which does not appear to be extant". However, Kubesov (1974) devotes chapters 4 and 5 to analysing that commentary (from a manuscript in the British Museum), and the publication of a Russian translation of al-Fārābī's commentary on Ptolemy's *Almagest* was announced by B. A. Rozenfel'd on p. 109 of the first issue of this Journal.

Toomer's edition of Diocles is a valuable contribution to the history of Greek and Arabic science.

Note on the Text

Dr. N. Kanawati has examined the reproduced manuscript, and he informs me that Toomer has made a very accurate translation of the difficult non-mathematical introduction (sentences 1 to 37); except that in the opening invocation the phrase "grant long life" is much more likely to be "grant help", i. e. *a'm* instead of *a'mir*. The word *hattā* (= till, to, even), repeated in sentences 3 and 4 in the Arabic transcription, should certainly be rendered *matā* (= when). Compare these two instances with the way *hattā* is written in sentences 22, 24, 36 and 37. Curiously however, Toomer's translation in both cases is the correct one - "when". The emendation of the important corrupt name (in sentences 3 and 4) to "Zenodorus" is probable, but hardly "certain", as Toomer asserts.

G. J. TEE

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10-16 deal with the doubling of the cube. (Propositions 6 and 9 are triviahties, which Toomer considers plausibly to be spurious additions to Diocles' text.) Propositions 1, 4 and 10 contain the earliest known treatment of the focus and directrix of the parabola — the *Conics* of Apollonius treats the foci of ellipses and hyperbolae, but it is remarkable that none of his surviving writings mention the focus of the parabola.

The theory of conic sections was invented by Menaechmus (mid-4th century), who named the 3 types as the "section of an acute-angled cone", "section of a right-angled cone" and "section of an obtuse-angled cone"; whereas we use Apollonius' names of "ellipse", "parabola" and "hyperbola" respectively. Archimedes (killed in 212) used Menaechmus' "cone" names, even though he effectively defined the curves by their equations in Cartesian coordinates, rectangular and even oblique. Diocles consistently calls the parabola a "section of a right-angled cone". Ellipses and hyperbolae occur only in his proposition 8, and there he uses their modern names, supposedly invented by his exact contemporary Apollonius. Could the *Conics* have been 'published' while Diocles was writing his book, inducing him to change his concept of the conic sections? Toomer suggests alternatively a modification of the accepted history of conic sections, according to which the names "ellipse" and "hyperbola" were invented together with the "coordinate" definition of the curves, and Apollonius standardized those names instead of inventing them.

Eutocius quoted Diocles' proposition 7, but he re-wrote propositions 8,10,11,12 and 13 to accord with the geometric style (Apollonian) regarded as orthodox in his day. In particular, as had been suspected by some previous investigators, the references to the *Conics* in Eutocius' version did not occur in Diocles' text. It is noteworthy that Diocles refers 4 times to a flexible strip of horn, used exactly like a modern draughtsman's spline for drawing a smooth curve through a set of points.

The 16 diagrams omitted from the manuscript have been restored most effectively by Toomer. Geometrical texts can permit such complete reconstructions of missing diagrams, an interesting contrast with, say, a biological text, where such a reconstruction would usually be impossible.

On p.23 Toomer refers to an elegant construction of a parabolic mirror with a given focal distance, which he ascribes to Abu'l-Wafa' (mid 10th century), and which has been printed in French and in 2 Russian versions. Toomer notes that Krasnova's translation was made from a manuscript (in Istanbul) of Abū'l-Wafā's book *On Geometrical Constructions*, but that the translation by A. Kubesov (al-Fārābī, *Matemancheskije traktaty*, "Mathematical Treatises", in Russian, Alma-Ata, 1972, pp.104-106), was made

book had been translated into Arabic, since Eutocius' extracts say nothing about burning mirrors (except in the title).

A few years ago Dr. Fuat Sezgin directed G. J. Toomer's attention to an Arabic manuscript of mathematical writings in the Shrine Library at Meshhed in Iran, including an Arabic version of Diocles' treatise *On Burning Mirrors*. That manuscript (dated A.H. 867 = 1462/3) is a carelessly written version of an anonymous well-written translation of Diocles' work, and it is the only known manuscript of that work (apart from an inferior transcript of that Meshhed manuscript, now in Dublin). Blank spaces are left in the manuscript where the diagrams should have been inserted.

Toomer's admirable edition consists of Preface and Contents, then an Introduction (pp.1-33), the edited Arabic text with facing English translation (pp. 34-113), photographs of the entire Arabic manuscript of Diocles' treatise (pp.114-137), Commentary (pp.138-175), Appendix A with text and translation of Eutocius' excerpts (pp.177-201), Appendix B with other ancient and mediaeval proofs of the focal property of the parabola (pp.202-204), Appendix C (by Otto Neugebauer) on Archimedes' problem and Diocles' solution (pp.205-212) Appendix D (also by Neugebauer) on a non-standard parabolic mirror (pp.213-216), Bibliography (pp. 217-223), Index of Technical Terms in Arabic (pp.224-238) and a General Index (pp.239-249). The elegant printing of the Arabic text was generated by a computer; but it is amusing to observe that the 12 pages of Eutocius' Greek excerpts (with elaborate textual apparatus) are reproduced from handwriting, although Greek words and phrases are printed neatly in the Introduction. There can have been few mathematical books of recent times in which some footnotes have been written so casually in Greek.

One of the most important features of the Arabic text is that it enables Toomer to determine the date of Diocles. The 4th and 5th sentences associate Diocles (in Arcadia) with a person whose name is rendered corruptly, first as 'Byūdām-s and then as 'Yūūdām-s; in view of the careless writing of the Meshhed manuscript these corruptions are emended by Toomer to Zinūdūrus, which corresponds to Zenodorus. Now, Zenodorus was a mathematician of the early 2nd century, best known from the fragments of his pioneering work on isoperimetric problems. Thus, Diocles appears to have been a close contemporary of Apollonius, the Great Geometer himself. This dating raises interesting questions about the chronology of the theory of conic sections.

Diocles' text contains 16 diverse propositions. Propositions 1, 4 and 5 deal with parabolic mirrors (including paraboloids of revolution), propositions 2 and 3 treat spherical mirrors, propositions 7 and 8 deal with a problem posed by Archimedes (expressible as a cubic equation), and propositions

as "social parasites", thrown out of society to meet their own fate. They inevitably sought ascetic living. And in their ascetic conditions and meditations they dreamed of rebirth for a happier rejuvenation. They tended to practice spiritual exercises and to utilize the herbo-metallic drugs of the Rasayana (p.117) to attain that end. But interestingly, the author comes out triumphantly and pointedly when he concludes by emphasizing his praiseworthy statement that "Indian medicine is unique in recognizing rejuvenation, and Indian philosophy is unique in aiming at immortality". (p. 118).

I must conclude by saying that here is an excellent literary contribution, a book deserving the attention of historians of science, cultural history, and the occult. It shows a link in the history of alchemy between countries and cultures in the East and in the West - a connection worth exploring and elucidating. It fills a gap in this new and dynamic topic by exploring the origins and development of alchemy, and the philosophy of this ancient "art".

SAMI K. HAMARNEH

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G. J. Toomer. *Diocles, On Burning Mirrors*. The Arabic Translation of the Lost Greek Original. Edited with English translation and commentary. Berlin-New York, Springer-Verlag, 1976. 249 p. Sources in the History of Mathematics and Physical Sciences. \$27.90.

In the 6th century Eutocius (a friend of Anthemius) produced a valuable series of commentaries on ancient Greek mathematics, written perhaps at Alexandria. In his commentary on Archimedes' *Sphere and Cylinder II* he quoted passages from several earlier authors on the problem of doubling the cube, and in particular he quoted (or rather, he paraphrased) several pages from a treatise *On Burning Mirrors* by a certain Diocles, employing conic sections and also a special cubic curve for solving cubic equations. That commentary by Eutocius was translated together with the text of Archimedes into Arabic and then into Latin (first by Wilham Moerbeke in 1269, translating from the Greek text), and later into many modern languages. They have been printed together in every major edition of Archimedes since the *editio princeps*, in 1544.

Much controversy has raged over the dating of Diocles, with various investigators suggesting dates from the 3rd century B.C. to the 1st. The full Greek text of Diocles is lost, but in 1905 Eilhard Wiedemann drew attention to a 14th-century Arabic encyclopaedist's reference to Diocles having proved that burning mirrors should be paraboloidal; which suggested that Diocles'

Herbs were plentiful, easy to secure, and most convenient to gather and utilize. Soon the herbometallic drugs developed. Finding and compounding such "miracle drugs and panaceas" led to the belief in rejuvenation, and eventually to immortality—the final goal of Rasayana. Here enters, likewise, the philosophic-religious thinking and exercises—yoga.

This reviewer disagrees with the author in identifying such a process with the elixir (Arabic *ikṣīr*) of the Muslim alchemists. Basically, the *ikṣīr* (or the philosopher's stone) is considered to be that special element or compound that, once prepared and "isolated", when treated with lesser metals transforms them into silver and gold. This Islamic notion of alchemy based on Greek writings embodies the rational concept that elements are transformable from one condition to another, hence from one metal into a more honorable one under the right amount of pressure, temperature, and other natural forces and conditions. To the alchemist, this meant the application of fire and other techniques and "potent" ingredients including the elixir to speed up the work of nature. His chemicals, fire, drugs, and equipment achieve in a very short interval what might take nature a long time to attain.

Indian alchemists introduced instead, imaginary and possibly pagan religious and philosophical practices, exercises, and theories quite foreign to their Muslim counterparts. The Indian alchemist believed in resurrection of the body as explained in Christian teachings as well as in heathen mythology. Here it is believed that the perishable part of the human put on the imperishable nature, and the mortal that is capable of dying put on immortality, acquiring freedom from death. These constituted the true precepts of Indian alchemy as explained by the author.

In reviewing and examining several original Arabic alchemical treatises even those abounding with symbolism, this reviewer found that Muslim alchemists were primarily seekers of material riches. Religious and spiritual values and rewards were found there no more than in contemporary writings in the arts and sciences. More "piety" entered into later compilations as a cover-up for failure, or as a hypocritical cloak put on for protection, or as a ray of hope amid continuous disappointments in achieving what had been sought in vain. Much "spirituality" was perhaps to deceive or for self-deception. In the Arabic alchemical literature, *kunīyā* is essentially an art, an honorable one (*ṣund'ah sharifah*) by which material ends are attained and riches gained with high prestige. It was not primarily intended to promote imaginary spiritual values or ascetic dreams and religious aspirations.

In fact, one finds it difficult to appreciate the logic followed by the author in assuming the original theory for ascetic rejuvenation and immortality as the origin of alchemy. He states that senior citizens were looked upon

Book Reviews

S. Mahdihassan. *Indian Alchemy or Rasayana in the Light of Asceticism and Geriatrics*, New Delhi (India), Institute of History of Medicine and Medical Research, 1977. x + 139 pages, \$5.00.

Here at last is a book on alchemy in India that departs from the traditional historical studies carried out in the West for the last two centuries. It makes for some of the finest reading on the subject. Although this reviewer disagrees with the author on many essential interpretations, this in no way minimizes the importance of a praiseworthy contribution to the history of alchemy.

For clarity and organization, Dr. Mahdihassan divides this brief text into over sixty chapters—a case of oversimplification. But the reader will greatly benefit from its objective, straightforward approach and thoroughness.

Following a foreword by Prof. S. H. Nasr, the author presents a very useful introduction summarizing his analysis of the topic and the discussions that follow. He also gives a select bibliography and seven previously published illustrations. In the discussions, he asseverates the antiquity of alchemy in India, associating its origin with yoga. He refers to this "art" as a living "cultural fossil", the product of alchemists who led a life of asceticism and sought geriatric treatment. He explains how human concepts and the application of asceticism changed man's belief from animism to dualism in a developed society realizing the creation process. Here the interpretation of how the two opposite sub-souls of male and female (the Yang and Yin of China and the Brahman and Atman of India) in their union led to immortality—the dream and goal of Rasayana. This, in the author's opinion, is the source of Indian alchemy defined by Patanjali as the Rasayana. It devotes health restoration, and with its specially prepared medications causes rejuvenation and makes one immortal. At this point, the author introduces the Indian deity, Shiva, who modified Rasayana and founded alchemy, which in turn modified him. The connection, however, seems the result of legendary traditions and folklore rather than a historical development. The insistence of the author upon defining the exact origin of alchemy, and upon naming its founders seems to be a well-nigh unattainable pursuit.

To interpret the appearance of Rasayana, the author skilfully describes the impact of two disciplines: medicine and philosophy, or rather, Indian philosophic-religious thinking. Since healthy living, virility, and longevity were the alchemist's primary objectives, medicine then entered the picture.

rabbinical text is placed between the two treatises written by Ibn Mu'ādh, namely *Kitāb majhūla* (fols. 49-74) and the *Maṭrah al-shu'ā'āt* (fols. 76-81), it clearly refers to the *Kitāb al-asrār* (fols. 1-48) because it is the only one in which mechanical devices, corresponding to Ishāq b. Sid's allusions, are mentioned.

All this, of course, agrees with the fact that all the dates mentioned in the manuscript (until fol. 105) correspond to the reign of Alfonso X. We have, therefore, the only specimen remaining of a manuscript copied in his Toledan court. The link suggested by Hill, between the use of mercury as a source of power in one of the clocks described in the *Kitāb al-asrār* and in another one contained in the *Libros del saber de Astronomía*, becomes very probable.⁴

4. Furthermore the *Libro de las Armeillas* quotes Ibn Mu'ādh's system for *taqwīm al-huyūt* in a way similar to Ibn Mu'ādh's in his *Maṭrah al-shu'ā'āt* which, as we have seen, is found in the manuscript.

Note

The "World Directory of Historians of Mathematics", first published in 1972, has just appeared in a second, revised and much enlarged edition. Listed are about 1200 scholars who are devoting at least part of their time to teaching and/or research in the history of mathematics. Besides the current address, the main fields of interest of each person is given. Indexes by fields and by countries follow the alphabetical list.

Prepared by K. O. May (1915-1977) and Laura Roebuck, the new edition (iv + 92 pp.) may be ordered from the International Commission on the History of Mathematics, 11 Evergreen Gardens, Toronto, Ont. M4G 1C4, Canada. Price: \$7.00 if payment is included with order; \$1.00 extra for postage on billing with shipment.

C. J. SCRIBA

NOTES AND CORRESPONDENCE

A Further Note on a Mechanical Treatise Contained in Codex Medicea Laurenziana Or. 152

MARIA VICTORIA VILLUENDAS*

The importance of the Codex Medicea Laurenziana Or. 152 has recently been emphasized by Drs. D. R. Hill¹ and A. I. Sabra.² I also have been acquainted with this manuscript since 1973, although at that time, I was mainly interested in another of the works contained in it: the *Kitāb majhulāt qasī al-kura* by Ibn Mu'adh al-Jayyānī which was the main subject of my Ph. D. thesis.³ Therefore I have a certain knowledge of the Ibn Mu'adh style which allows me to confirm Sabra's hypothesis: I do not think Ibn Mu'adh can be considered the author of the *Kitāb al-asrār fi natā'ij al-afkār* and agree with Sabra concerning the name of the author (Aḥ)mad or (Muḥam)mad b. Khalaf al-Murādī. The *nisba* al-Murādī appears frequently in Ibn Hayyān's *Muqtabis* and in other Andalusian texts of the 10th and 11th centuries. He might, of course, be the Abu'l-Ḥasan 'Abd al-Raḥmān b. Khalaf b. 'Asākir mentioned by Ṣā'id of Toledo, as proposed by Sabra.

In the preliminary survey of the *Kitāb al-asrār* certain data contained in fol. 75 should be taken into consideration. In it there is a text written in Andalusian dialect, but in rabbinical Hebrew script. I have been able to read it thanks to the very valuable help of Professors Fernando Diaz, David Romano and Juan Vernet of Barcelona University. The text states that Ishāq b. Sid, the famous Jewish translator and scientific collaborator of the Castilian King Alfonso X, was the copyist of the manuscript. He knew only one manuscript of the work, the one he used, which increased his difficulties in understanding the *Kitāb al-asrār*. But his efforts led him to an almost complete reconstruction of the majority of the models described in the work, and he failed to understand only a few of them due to the incomplete state of the original manuscript or to difficulties impossible to overcome. Though this

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1. Donald R. Hill, "A Treatise on Machines by Ibn Mu'adh Abū 'Abdallāh al-Jayyānī" *JHAS*, 1 (1977), 34-46.

2. A. I. Sabra, "A Note on Codex Bibliotheca Medicea-Laurenziana Or. 152" *JHAS*, 2 (1977), 276-283.

3. Read at the University of Barcelona on the 2nd October 1975, now in press.

Thus his contributions to our field, while rivalling in significance those of many professionals, were made by an amateur. They were carried through in time snatched from the requirements of a demanding profession. All the more remarkable was it that, for example, any book review written by Hermlink was the fruit of deep and meticulous examination of everything the volume contained. This quality of his was the source of shamed admiration on the part of those of us who resent every minute spent in reviewing the books of others as being time lost to one's own work.

His own publications in the history of science were wide ranging, and included: recreational mathematics, number theory, magic squares, anagramma methods, trigonometry, and Archimedean treatises which have survived in Arabic only. To these topics he brought all the virtues traditionally associated with German scholarship. His untimely death is a grievous loss to the many colleagues who counted him a personal friend, and a setback to the history of Arabic science.

Éloge

HEINRICH HERMELINK



11 DECEMBER, 1920 – 31 AUGUST, 1978

*By E. S. Kennedy**

As an infant, Heinrich Hermelink was a victim of poliomyelitis, and survived only as a severe cripple. Hence for him mere day-to-day living, let alone professional accomplishments, represented a continuing triumph over dire adversity. The physical disability made any public appearance inevitably conspicuous, and his wheelchair, his gracious wife, and he made up a poignant group familiar to historians of science attending scientific meetings.

In 1947 Hermelink graduated in physics from the Munich Technische-hochschule. Following this he studied oriental languages and the history of mathematics at the University of Munich, taking the doctorate in 1952.

From a remark dropped by him in a conversation, one gathers that an academic career would have been most congenial (his father was a professor of church history at the University of Marburg), but continuing medical treatment demanded a more lucrative vocation. He entered a patent agency in 1952, and in 1957 commenced independent practice as a patent lawyer.

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٦- باب في معرفة القبلة من الرسالة في العمل بالاسطرلاب لابسن التطاح

المصدر : مخطوطة لندن المكتبة البريطانية اضافية ٩٦٠٢ ، ق ١٨ ط - ١٩ و

باب في معرفة القبلة اذا اردت معرفة القبلة بهذا معخذ ارتفاع الشمس وضعها على مثل ارتفاعها واعرف سمتها واستخرج منه الجهات الاربع على ما بنيت في الباب قبل هذا فاذا عرفته فاترك الاسطرلاب على حاله ولا تحركه على ما هو عليه ثم در العصادة دون تحريك الاسطرلاب على ثلاثين درجة في ربع الارتفاع فما قانت الشطية من الجهات فتلك هي القبلة بقرطبه وما قرب منها وهذا القبلة بقرطبة على خمس واربعين درجة ووجدت في معلقات عن ابي القاسم الصنيرى تضع^١ العصادة على ثلاث^٢ وعشرين درجة اذا كان عرض البلد لَحَ لَ هذا الذي ذكرته هو مذهب اهل صناعة التعديل واما الفقهاء فيرون الربع كله قبلة والمسجد الجامع بقرطبه على ستين واكثر مساجد قرطبة على مذهب البتاني رحمه الله وفيها ما هو على ثلاثين فال اردت معرفة القبلة بالليل فاستخرج الجهات الاربع على ما تقدم ثم در العصادة الى ربع اجزا الارتفاع على ما شئت من الاعداد التي ذكرت ان القبلة عليها بقرطبة فافهم .

التحقيق : ١ - في الاصل : يضع ٢ - في الاصل : ثلاثا .

انقبله ان شا الله [وان] اردت ان تعرف ذلك بوجه اخر نستوحى (؟) وقت مغربها في اليوم السادس [عشر] او السابع عشر او الثامن عشر من يونيه فانها في هذه الثلاثة ايام يكون مغربها واحد فتقيم عودا قايما مستويا او تقف انت قايما مستويا فحيث انتهى صلك او ظل العود فهو سمت القبلة بمشية الله تعالى وتوفيقه والعمل بوديائك [!] الى شئ واحد وبالله التوفيق .

٣- قطعة من كلام موسى بن ميمون في عمل البلاطة

المصدر : كabanillas ص ٤٠٤ (ويلاحظ ان الاصل مكتوب بالحروف العبرية)
رحامة تسمى في الارض وترسم فيها خطوط مستقيمة مكتوب عليها اسماء الساعات وهي دائرة وفي مركز تلك الدائرة مسمار قائم على روايا قائمة كلما سامت ظل ذلك المسمار لخط من تلك الخطوط علم كم ساعة مضت من النهار واسم هذه الآلة المشهور عند المنجمين البلاطة .

٤- قطعة من كتاب في الأنواء للحسن بن علي الأموي القرطبي

المصدر : مخطوطة اسكوريال ٩٤١ ، ق ٢٦ ط
القول في رسم القبلة تعلم القبلة بالاندلس بان تصنع القطب على كتفك الايسر ثم تستقبل اجنوب فما لقي بصرك فهو القبلة والقطب .

٥- قطعة من الرسالة في العمل بالاسطرلاب لابن الصفار

المصدر : مياس ، النص العربي ، ص ٦٥
وانثلاثون درجة من الربيع الشرقي الجنوب التي هي سمت للقبلة بقرطبة وما قرب منها . . .

لوحة او حجرة^١ مستوى السطح فتدير فيه دائرة دورها قدر الشبر وتقيم في مركزها قامة قدر نصف القطر على اعتدال ثم ترصد طله في صدر النهار فاذا بلغ طرف الدائرة علم عليه بنقطة قبل أن تميل فاذا رالت الشمس ترصده ايضا فاذا بلغ الجانب الاخر من الدائرة علم عليه بنقطة ثم تقسم ما بين النقطتين على حرف الدائرة نصفين وتعلم على وسط . ° بنقطة ثم تخط خطا من ارض القامة الى نقطة الوسط فيكون هو خط [الزوال]^٢ فاذا وقع ظل القامة على الخط فهو نصف النهار بالاعتدال ثم تاخذ البلاطة حين يقع ظل القامة على الخط يشتها في مكان مشرف على اعلى^٣ حر معجون^٤ اثبتا وتستقبل بوجه الساعات جهة الجنوب حتى يقع ظل المرودين على الخطين اللذين هما احمر السادسة واول الساعة ثم تتقن لصوق البلاطة بالحر^٥ اتفانا حسنا ليلا تربطها الرياح ثم نتعاهد النظر اليها اي وقت اردنا ان نعلم ما معنى من ساعات النهار وما نقي فانه لا يخفى عليك ذلك وهذا امر واضح فاعمل في ذلك كله من البلدان ان شا الله تعالى وهو المستعان وبه التوفيق وهذه صورته . . .

(٤ - ٤) - في الاصل - لوح او حجر ه - كلمة غير بيّنة في الاصل ٦ - كلمة غير بيّنة في الاصل
(٧ - ٧) - هكذا في الاصل ٨ - في الاصل بالحر .

٢- بابان في معرفة ارتفاع الشمس نصف النهار بقرطبة وسمت القبلة بها من كتاب الأسرار في نتائج الأفكار

المصدر . مكتبة فلورنر لوريتريانا ١٥٢ . ق ٤٨ ط

ارتفاع الشمس عند حلولها بروس البروج بقرطبة ارتفاعها عند حلولها براس
الجلدي كارتفاعها عند حلولها براس الدلولج . الحوت م . . الحمل نال . . .
الثور صج . . . الجوزا عب . . . السرطان عه . . . الاسدع . . . السنبلة صج .
الميزان نال . . . الحوزا م . . . القوس لج الحمل نظيره الميزان نظيره الحمل
الثور نظيره العقرب نظيره الثور . . . السنبلة نظيره الحوت نظيره السنبلة

باب في معرفة سمت القبلة [في مد] بنة قرطبة يستوحى طلوع اشمس يوم
خمسة عشر او يوم ستة عشر [او يسو] م سعة عشر من دحبر فانها في هذه الثلاثة ايام
يكون مطلعها واحد [فهي] اقصى مطلعها في الجنوب ومن حيث طلعت هو سمت

Thus there were several accepted *qibla* values in Cordova, and even astronomers such as Ibn al-Naṭṭāh preferred to invite his readers to choose their favorite one rather than take the trouble to compute one consistent with the mathematical and geographical knowledge of his time.

Appendix B

Arabic Texts

In this appendix I present the Arabic texts of (1) the chapter on the "sundial" by Ibn al-Saḥḥār taken from the *K. Naṭā'ij al-afkār* of al-Murādi; (2) the anonymous chapters on the meridian altitude and *qibla* at Cordova from the same work; (3) the passage on the same "sundial" by Maḥmūd; (4) an extract from the chapter on the *qibla* in the treatise on folk astronomy by al-Ḥasan b. 'Alī al-Umawī; (5) the passage on the *qibla* at Cordova in the treatise on the astrolabe by Ibn al-Saḥḥār; and (6) the chapter on the *qibla* in the treatise on the astrolabe by Ibn al-Naṭṭāh.

١- باب في عمل البلاطة لابن الصفار كما ورد في كتاب الأسرار في نتائج الأفكار لابن خلف المرادي

المصدر : مخطوطة مكتبة فلورنزا لورينزيانا ١٥٢ ، في ٤٧ و - ٤٧ ط

باب في عمل بلاطة تعرف^١ بها ساعات النهار على الحقيقة لابن الصفار تأخذ
حجر كتان^٢ اورخامة وتنقش فيه على ما يأتي ذكره في شكله المصور ويكون الوسط
الذي بين الساعات ثانيا خارجا عن وجه الساعات فيكون الوجه الواحد شرقيا يدل على
ساعات النصف الاول من النهار والثاني غربيا يدل على ساعات اخر^٣ النهار ثم تقيم
لكل واحد مرودا^٤ مشتا في مجتمع الساعات على اعتدال واستوا يكون طول كل واحد
قدر عقدتين^٥ ثم^٦ تعتمد^٧ الى^٨ مكان ما من الارض مستويا وتجعل^٩ فيه

التحقق . ١ - في الاصل : يعرف ٢ - في الاصل - اول (٣-٣) - غير واضح في الاصل

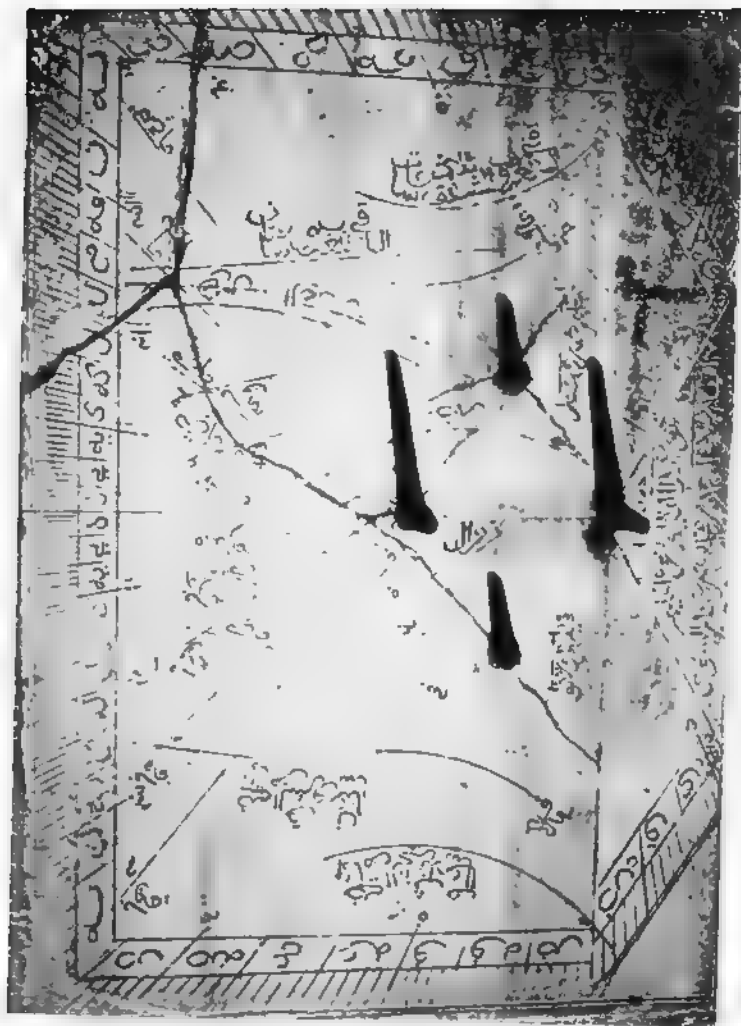


Plate 6: The sundial of the Mosque of Sidi Okba in Qayrawan.

(Courtesy René Rohr)

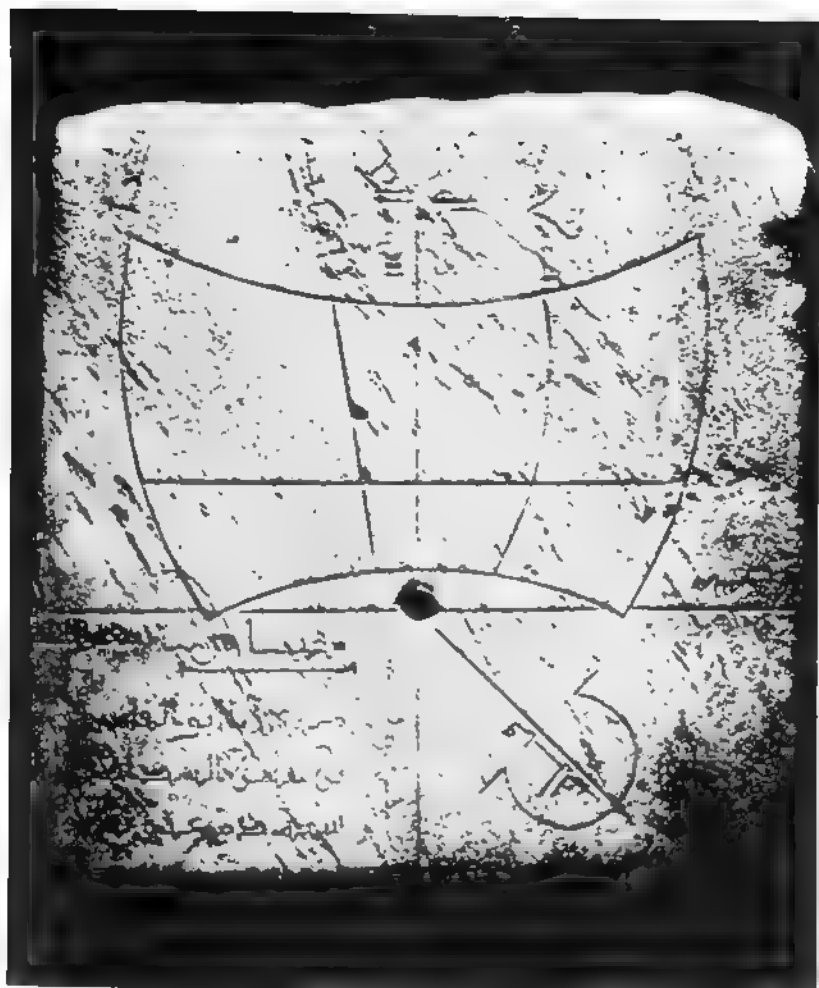


Plate 5 A fourteenth-century Tunisian sundial displaying the times of prayer.

(photo Alain Brieux, courtesy Francis Maddison)

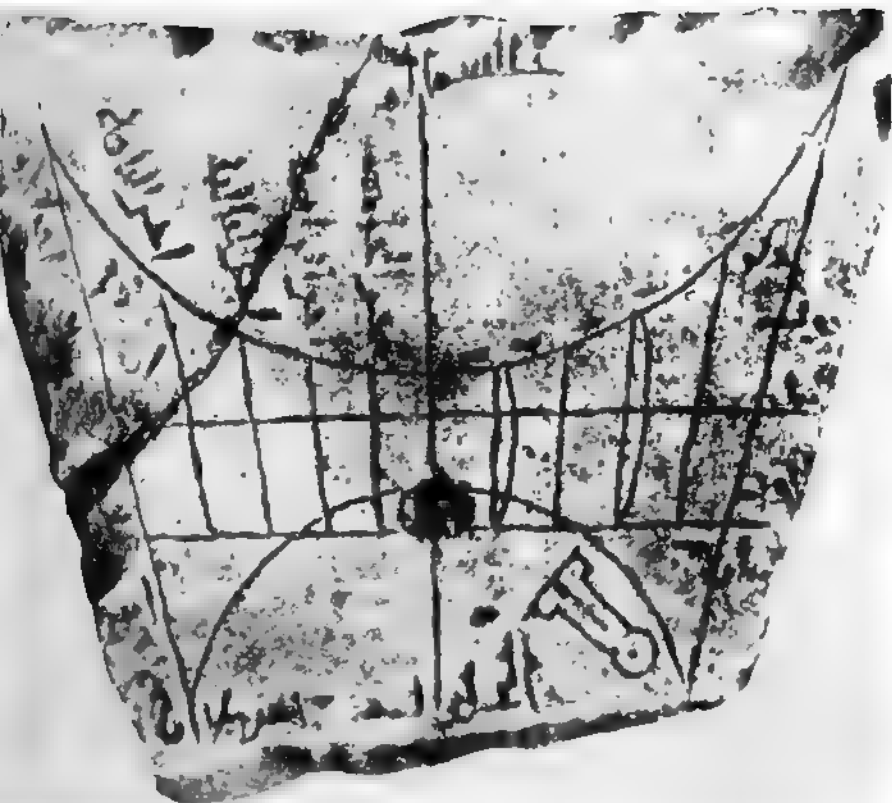


Plate 4: The Granada sundial.

(photo Abumaz)

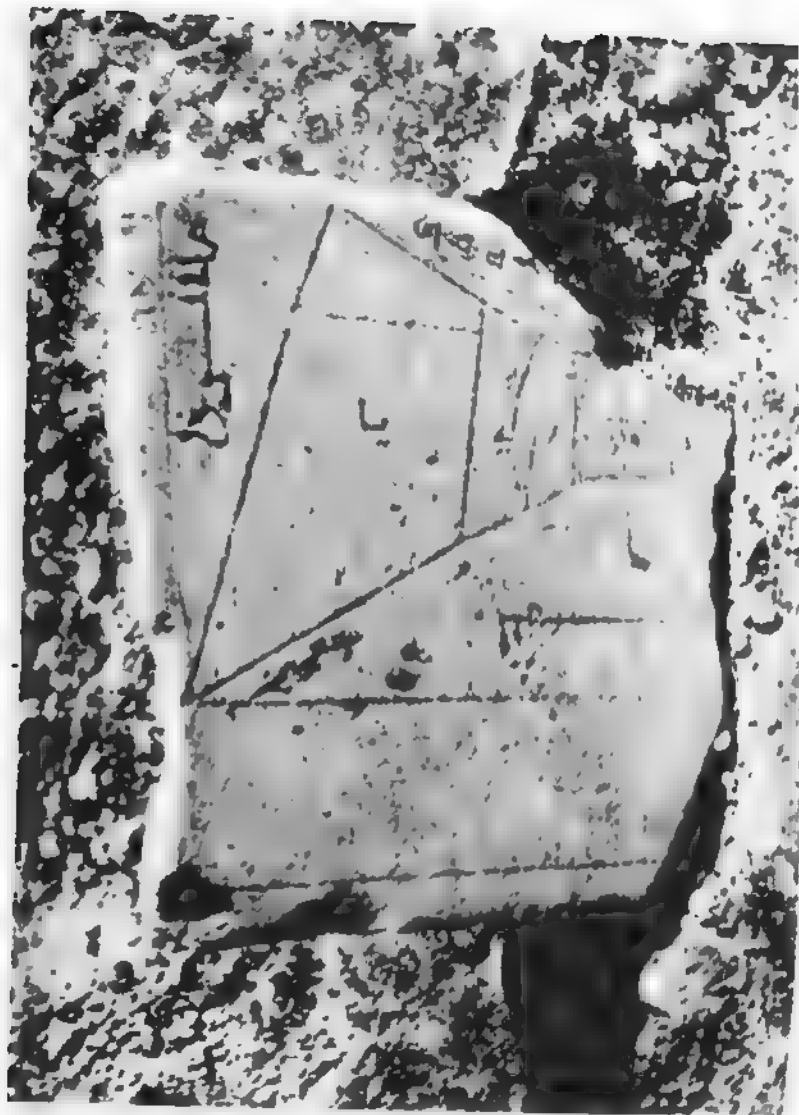


Plate 3: The Almeria sandial.

(photo Abumax)



Plate 2: The sundial of Aḥmad b. al-Saffār

(Courtesy *Museo Arqueológico Provincial de Córdoba*)

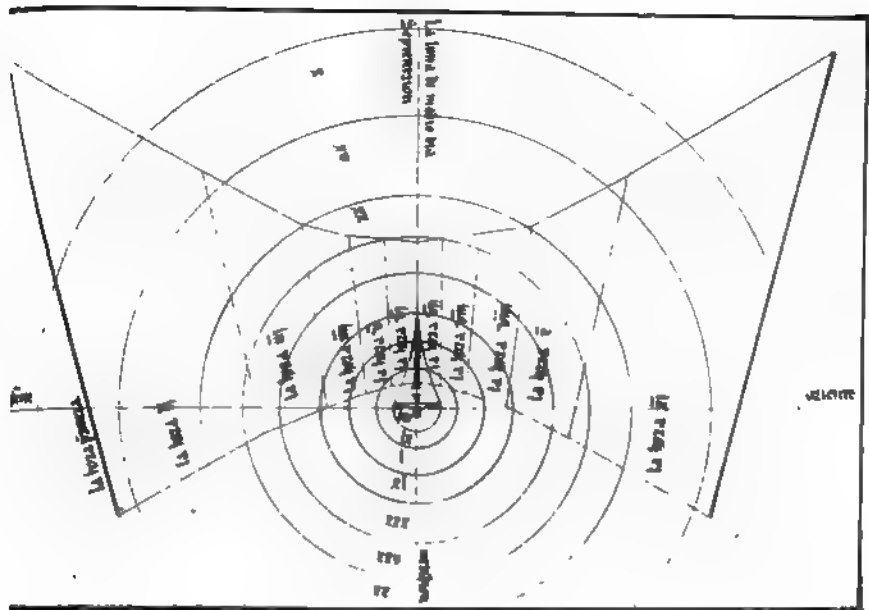


Plate 1. The horizontal sundial illustrated in the *Libros del Saber*.

(Courtesy Harvard University Library)

In his geographical tables¹⁵ al-Battānī gives the following coordinates

	L	φ
Cordova	27;0°	38;38°(?)
Mecca	71; 0	21;40

With his geometrical construction we derive from these coordinates that the *qibla* at Cordova is about 23° S. of E., which is precisely the value attributed to "the astronomers" by Ibn al-Naṭṭāh.¹⁶ I have no information on Abu'l-Qāsim al-Su'ry who is quoted by Ibn al-Naṭṭāh in the same context. The "correct" *qibla* for these coordinates, derived using the accurate mathematical formula, is 11° S. of E., and this is only 1° off the modern *qibla* for Cordova, which is 10° S. of E.

Ibn al-Naṭṭāh's remark that the *Jāmi'* mosque in Cordova is at 60° (S. of E.) is incomprehensible to me because, as noted above, the Great Mosque of Cordova has its *qibla* wall due south. Ibn al-Naṭṭāh's other statement that most of the mosques in Cordova are laid out according to the opinion of al-Battānī, that is, at 23° S. of E., or at 30° S. of E., that is, the direction of the rising sun at the winter solstice, will be, or should be, of interest to historians of Andalusian architecture.

From the Granada sundial we know that south-east was also used as the *qibla* in Andalusia. The direction 45° S. of E. would have been handy for the *qibla* in Andalusia since, as Ibn al-Naṭṭāh says, the legal scholars thought that the whole (south-eastern) quadrant was the *qibla*. The *qibla* indicator on the Tunisian sundial also points due south-east, and although this *qibla* is grossly inaccurate for Tunis, it is a happy compromise between due east and due south, both of which directions are attested for *qiblas* of medieval Maghribi mosques.¹⁷

15. Nallino, III, pp. 234-242. The reading of the minutes in the latitude of Cordova appears to be in error.

16. Other medieval coordinates yield similar but not identical results. For example, al-Marrākushī, an astronomer of Moroccan origin who worked in Cairo ca. 1280, recorded the following geographical coordinates (*Siddiqat-pāz*, I, pp. 202-204 and 315-317)

	L	φ
Cordova	27;0°	38;30°
Mecca	71;0	21;0

Using al-Battānī's method I derive a *qibla* of 21° S. of E. Again, in the *Toledan Tables*, a hodge-podge of tables culled mainly from the *Zij*s of al-Battānī and al-Khwārizmī, and compiled in Toledo in the thirteenth century, we find the following coordinates (Toomer, pp. 134-139, nos. 3 and 16):

	L	φ
Cordova	27;20°	38;30°
Mecca	67;0	21;0

These coordinates are derived from those of Ptolemy, and were used by al-Khwārizmī. I compute that they yield a *qibla* of 20° S. of E. using al-Battānī's method.

17. Cf. King 2, p. 190-191

The treatise on the use of the astrolabe by Ibn al-Šaffār,⁴ published by J. Millas Vallicrosa, contains a remark (Appendix B, extract 5) that the *qibla* at Cordova is 30° south of east.⁵ The treatise on mechanical devices entitled *Kitāb al-Isrār fī nutā'ij al-afkār* by Ibn Khalaf al-Murādi⁶ concludes with a chapter on the *qibla* at Cordova (Appendix B, extract 2), in which the author states what is equivalent to an assertion that the *qibla* there is in the direction of the rising sun at the winter solstice. The two directions given in these two sources are in fact the same,⁷ and al-Murādi's definition explains the value of Ibn al-Šaffār.

The local direction of the rising sun at the winter solstice was also taken as the *qibla* in early Muslim Egypt.⁸ The justification for such *qibla* determinations appears to result from an early Islamic tradition of using *al-Jady*, the Pole Star, to find the *qibla*.⁹ As we have seen in the treatise of al-Hasan b. 'Alī al-'Umwī, what was intended was that if one stood with one's back to the Pole Star one would be facing the *qibla*. Since one would be in fact facing due south, this injunction is valid only for points due north of Mecca. However, when Muslim domination extended eastwards and westwards, another interpretation was given to the injunction, and *al-Jady* was taken to refer to the sign of Capricorn. At the winter solstice the sun is at the first point of Capricorn; its rising point was used for the *qibla* in Egypt and Andalusia.

A fourth discussion of the *qibla* at Cordova occurs in a treatise on the use of the astrolabe by an individual named Ibn al-Naṭṭāh,¹⁰ extant in the unique copy MS London B.L. 9602,1 (fols. 1v-24v, copied ca. 600H). Ibn al-Naṭṭāh's treatise was apparently well esteemed in its genre: a note in MS Cairo Dār al-Kutub hay'a 10, fol. 39v, copied after 1163H by a Maghribi astronomer, states that the best treatises on the astrolabe are these of Ibn al-Naṭṭāh and of Ibn al-Samh.¹¹ Ibn al-Naṭṭāh's remarks are found on fols.

4. On Ibn al-Šaffār see note 9 above.

5. Millas, p. 65 of the Arabic text.

6. See note 22 above.

7. For $\phi = 38^\circ$ (the latitude of Cordova is actually 37.53°) and $\epsilon = 23.35^\circ$, the azimuth of the rising sun at midwinter is 30.31° S. of E. For $\phi = 38.30^\circ$, a value popular with Andalusian astronomers, the azimuth would be about 30.45° S. of E.

8. See the article *Kibla* in *Et.*

9. See, for example, the treatise on folk astronomy by Ibn Qutayba (fl. 850), p. 122.

10. Ibn al-Naṭṭāh and the London manuscript of his treatise on the astrolabe are listed in *Suwar*, No. 499. He is not mentioned in Millas (?), and I have no other information on him.

11. On Ibn al-Samh see *Sagun*, V, p. 356 (the treatise on arithmetic contained in manuscripts in the Escorial and in Berlin is not by Ibn al-Samh) and VI, to appear. His treatise on the astrolabe is extant in the unique copy MS London B. L. 9602,2 (fols. 25v-55v, copied ca. 600H, defective at end). This treatise of course contains a chapter on the determination of the *qibla*, but no values are given for anywhere in Andalusia.

comprises four main sets of markings: (1) graduations around the edge of the sundial from which the hour-angle can be read using the shadow of a thread attached at the centre of the graduations and oriented in the direction of the celestial pole; (2) markings displaying the seasonal hours since sunrise and before sunset; (3) markings for the *zuhr*²⁸ and *‘asr*, the latter being duplicated; and (4) markings displaying time relative to daybreak and nightfall. The first part of the sundial is called *al-musatarā* in late medieval Arabic,²⁹ and the development of this kind of hour-angle dial in medieval Islam remains to be studied. On the second part of the sundial there are no shadow-traces for the equinoxes and solstices, and this feature, not attested on any of the Egyptian, Syrian, or Turkish sundials currently known to me, may be the result of a Maghribi innovation in gnomonics: since it is so difficult to draw acceptable hyperbolae, leave out the shadow-traces altogether.

Appendix A

Some Medieval Values of the Qibla at Cordova

Very few astronomical works compiled by Andalusian astronomers have survived in the manuscript sources, so that there is not much hope of recovering written material on the *qibla* in Andalusia.¹ Treatises which deal with the determination of the *qibla* without giving specific examples do not concern us here, and I have found references to the specific values of the *qibla* in Andalusia in only four Andalusian treatises. Details follow.

The treatise on folk astronomy written by the late twelfth century Cordova scholar Abū ‘Alī al-Hasan b. ‘Alī b. Khalaf al-Umawī,² which is extant in the unique MS Escorial ar. 941 (38 fols., ca. 800H), contains a statement (fol. 26v, see Appendix B, extract 4) that to find the *qibla* in Andalusia one should stand with the celestial pole behind one's left shoulder and face south. It was probably on this kind of authority that the Great Mosque in Cordova, which dates from ca. 785, was built with its *qibla* wall facing due south.³

28. In *Janin*, p. 210, the shadow increase at the beginning of the *zuhr* is given incorrectly as $\frac{1}{12}$ rather than $\frac{1}{6}$.

29. Cf. *Janin-King*, pp. 199-200 and 214.

1. For a brief introduction to the determination of the *qibla* in medieval Islam see the article *Qibla* in *EI*₂ by A. J. Wensinck (religious aspects) and myself (mathematical aspects).

2. On al-Umawī see *Sauer*, no. 323.

3. *Creswell* I, II, pp. 145-146 (repeated in *Creswell* II, p. 216) stated: '(The Mosque) is set, as nearly as can be measured, exactly north and south, although the direction of Mekka from Cordova is 10°14' S. of E'. A remark such as this reflects the misunderstanding of orientations of medieval Islamic buildings common amongst historians of Islamic architecture. Such orientations are usually to be explained in terms of medieval *qibla* values, if they can be explained at all.

888H. This treatise, arranged in 44 *fahs* with numerous diagrams but without tables, treats of the construction of horizontal sundials with markings for the hours and the prayer-times. This work merits detailed investigation.

(3) An anonymous treatise on the construction of a horizontal sundial displaying the seasonal hours for the latitude of Fez, 33;40°, is contained in MS Cairo Taymūr *riyāḍa* 141,6, pp. 146-156, copied ca. 1100H. The treatise contains tables displaying the shadow lengths and azimuths at each hour for both solstices, with values to two sexagesimal digits.

(4) An anonymous Maghribī treatise on the construction of a sundial displaying the times of the *ḡuhr*, and the beginning and end of the *ʿaṣr* (corresponding to shadow increases of $\frac{1}{4}n$, n , and $2n$) is contained in MS Cairo Ḥalīm *miqāt* 19,3+4, fols. 45v-58r, copied 1144H. The author states triplets of both azimuth values and shadow lengths for each of the three times at the solstices and equinoxes. Values are given to the nearest degree or unit, and are stated to be for the latitude of Fez (value not stated). The azimuth values given for the beginning and the end of the *ʿaṣr* are the same.

(5) An isolated table of coordinates for constructing a horizontal sundial displaying the seasonal hours for the latitude of Marrakesh, 31;30°, is contained in MS Cairo Taymūr *riyāḍa* 131,2, p. 1, copied ca. 1200H in Maghribī script.

(6) A treatise entitled *Rawḍat al-nāẓir fī kayfiyat waḍʿ khulūṭ fahl al-dāʿir* by Muḥammad al-Idrīsī is preserved in MS Cairo Dār al-Kutub *miqāt* 1169,2, fols. 11v-25v, copied 1223H. This treatise, arranged in 4 *bābs*, deals with the construction of a horizontal sundial with markings for the seasonal and equinoctial hours and the prayer-times, and it contains several tables computed for the latitude of Tunis, 36;51°. The author quotes other Maghribī writers named Ibn al-Najjār and Abū ʿAbd Allāh Muḥammad Kwynkh (?), author of a treatise on sundial theory entitled *lḥyaʿ al-mawāt fīʿl-basāʿiṣ wa-l-munḥarifāt*, as well as the two well-known Egyptian astronomers Ibn al-Majdī and Sibṭ al-Māridīnī.²⁶ The kind of sundial discussed in this treatise apparently became known in the Maghrib from the Muslim East, and its introduction there seems to have occurred rather late, that is, ca. 1600. One kind of late Maghribī sundial is illustrated in Plate 6, which shows the sundial of the Mosque of Sidi Okba in Qayrawan in Tunisia, constructed in 1258H (= 1842 A.D.) and recently discussed by L. Janin.²⁷ This kind of sundial is late, and not related to the Andalusian tradition. As Janin has shown, it

26. Suter, nos. 432 and 445.

27. See Janin, especially pp. 208-211.

preserved in the unique MS Florence Medicea-Laurenziana Or. 152, fols. 1v-48v, copied 664H (= 1266) in Maghribi script, and the passage occurs on fols. 47r-47v (see Appendix B, extract 1). The same type of sundial is described by another scholar of Cordova, namely, Maimonides.²³ In his commentary on the *Mishna* Maimonides gave a much more succinct account of the sundial than Ibn al-Ṣaffār. The text (see Appendix B, extract 3) translates as follows:

A piece of marble (*rukhāma*) is fixed on the ground and straight lines are drawn (as radii) with the names of the hours written on them (to form) a circle. In the centre of that circle there is a nail standing perpendicular (to the plane of the circle), and whenever the shadow of that nail is in the same direction as one of those lines, it is known how many hours of daylight have passed. The name of this instrument, which is used by the astronomers, is the *ballāja*.

Ibn al-Ṣaffār's text confirms that what is intended is to form a semi-circle with the diameter oriented east-west and the circular part towards the north. The twelve hour-lines are the radii at 15° intervals from west to east. There is no suggestion that the dial be oriented in the plane of the celestial equator, when it could indeed be used to display equinoctial hours before or after midday. Rather, the dial is horizontal, and it is assumed that the sun rises due east and sets due west, and that its change in azimuth is proportional to the passage of the seasonal hours.

A far more interesting instrument for timekeeping is described and illustrated by al-Murādi as the last of the thirty-one devices presented in his book (fols. 45r-46v). This is a horizontal dial of the kind known in other medieval Arabic sources as *shāmīla* or *musātara*, although in al-Murādi's text it is simply labelled 'a kind of *ballāja*'. This dial was as far as we know invented by al-Khujandi in the tenth century, although the one described by al-Murādi may be an Andalusian invention. In any case the Islamic tradition of horizontal dials in general awaits study.²⁴

(2) A treatise by the early fourteenth century Tunisian (?) astronomer Ibn al-Raqqām²⁵ is extant in MS Escorial ar. 918,11, fols. 68v-82v, copied

23. This passage is quoted without comment in *Cobanclas*, pp. 404-405. The original text was in Judeo-Arabic written in Hebrew characters.

24. See *Janin-King*, p. 199, and the references there cited. Al-Khujandi's treatise is currently being studied by Dr. R. Loreb.

25. On Ibn al-Raqqām (was he Tunisian or Andalusian?) see *Suter*, nos. 388 and 417, *Renaud*, no. 388, and *King* 2, pp. 191 and 192. All of his works merit detailed investigation.

and hence to date the sundial!²¹ For the Tunisian sundial I computed $\varphi \approx 37^\circ$, which corresponds quite well to Tunis. For the Cordova sundial I have derived $\varphi \approx 39\frac{1}{2}^\circ$, which serves Cordova. But I doubt that one should attempt to compute the latitude underlying sundials as crude as the Almeria or Granada sundials.

Conclusions

Rather than assert on the basis of our investigations of the only three sundials known from Islamic Spain that the Andalusian astronomers were not competent in gnomonics, we can only conclude that these three surviving specimens are not particularly impressive when viewed in the light of the sundial theory of Abbasid Baghdad. Are there any other sundials from Islamic Spain? A single dial could greatly add to our knowledge of Andalusian sundial construction.

Another source for our knowledge of Andalusian gnomonics would be treatises on the construction and use of sundials, but there are very few known treatises on this subject of Andalusian or even Maghribi provenance. Besides the treatise in the *Libros del Saber*, I know of only the following:

(1) A short passage attributed to Ibn al-Šaffār in a twelfth-century Andalusian treatise on mechanical devices by Ibn Khalaf al-Murādī²² describes at length a "sundial" for measuring the hours "correctly". The treatise is

21. In *de Oris* the Almeria sundial is dated to the end of the tenth century or the beginning of the eleventh by the following method: Measuring the eccentricity, e , of the "hyperbola" for the winter solstice as 2.00, and taking $\varphi \approx 36^\circ 50'$ for the latitude of Almeria, the obliquity of the ecliptic, ϵ , is determined using the relation $\cos \varphi = e \sin \epsilon$, and found to be $23^\circ 34'$. Newcomb's formula for the secular variation of ϵ is then used to derive an approximate date for the sundial.

22. On this treatise see King 3, p. 289, Hill, and Sabra. The chapter by Ibn al-Šaffār (*Sabra*, p. 289) is followed by a chapter on the determination of the meridian, correctly attributed to al-Battānī (fol. 47v-48r; *Sabra*, p. 290, states that this is anonymous), and by two anonymous chapters (both on fol. 48v) dealing with the meridian altitudes of the sun in the signs at Cordova and on the qibla at Cordova. These two chapters may be due to Ibn al-Šaffār (as suggested in *Sabra*, pp. 280-281). The solar meridian altitudes are based on latitude 38.30° and obliquity ca. 23.30° ; values are given to the nearest half degree for each zodiacal sign. On the value stated for the qibla at Cordova see Appendix A.

As Sabra has pointed out (*Sabra*, p. 278), the author of this treatise is named as . . . (?) Ibn Khalaf al-Murādī rather than the eleventh century scholar Ibn Mu'ādh as was assumed in Hill. However, Sabra read the last and only visible letter of the name preceding the word *ibn* as a *nūn* (= *n*), when it is actually a *dāl* (= *d*). From Toledo in the mid eleventh century there were two scientists named 'Alī b. Khalaf and 'Abd Allāh b. Khalaf (*Bleeker*, pp. 138-139) who cannot be the authors. Aḥmad b. Khalaf and Muḥammad b. Khalaf, both celebrated astrolabists of ninth-century Iraq (*Ibn al-Nadīm*, pp. 284-285), are also not candidates. Neither, most probably, are Muḥammad b. Khalaf al-Qurṭubī (d. 557/1162) author of a legal work listed in *Brackmann*, I, p. 185, or al-Ḥasan b. 'Alī b. Khalaf al-Umawī al-Qurṭubī (d. 602/1205-06), author of a work on folk astronomy listed in *Saber* no. 323.

XY measures the length of the gnomon, because it is about the same length as OW .

We now observe that the hour-lines divide equally the two east-west lines; this reveals the method by which they were constructed. But how did the maker construct the first and eleventh hour-lines, AB and CD ? Notice that AOD and BOC are more or less straight lines and that they are inclined at approximately 45° to the meridian. Notice also that OA and OC are roughly twice OB and OD . The reason why the maker might have used the approximation $OA \approx 2 OB$ is clear from Ibn al-Šaffār's sundial. Notice also that OA and OC are roughly twice the length x , but OA and OC should be about four times the length of the gnomon, so that x cannot represent the length of the gnomon. The directions that the maker chose for AOD and BOC are nice and symmetrical but not so reasonable.

Notice that the winter-solstice shadow at the 'aṣr, is in excess of the midday shadow OW by the length x . From this one might conclude that the length x was a measure of the length of the gnomon, but the relationship is fortuitous. Both the *zuhr* and 'aṣr curves have been drawn as arcs subtended by the seventh and ninth hour lines. If we superimpose the Cordova and Granada sundials we see that the error in the time of the 'aṣr displayed by the Granada sundial is about one hour.

In a recent publication I have discussed in some detail the Tunisian sundial mentioned above,²⁰ but at the time of writing that paper I was not aware of the existence of the Granada sundial. The Tunisian sundial displays four times of day with religious significance, including the *zuhr* and the 'aṣr prayers and a morning prayer at the same time before midday as the 'aṣr after midday. Each of the curves for these three times is drawn as an arc of a circle, as are the shadow-traces for the solstices. I have already proposed a method of constructing such a sundial, but I think that I may have placed too much emphasis on the possible use of calculation, or even tables of the kind well attested in the astronomical traditions of Egypt, Syria, and the Yemen, rather than geometrical construction, in the marking of this Tunisian sundial. I also now question the validity of trying to derive the local latitude for which such an approximate sundial was drawn, although it is certainly more valid than attempting to derive the value of the obliquity underlying the markings

20. King 2. In this paper the dimensions of the sundial are given (p. 187) as 24×34 cm.: read 24×24 cm. Also, the time of the *ṣaḥib* shown on the sundial (see p. 190) does indeed relate to the Friday prayers in the anonymous Moroccan treatise of sundials preserved in MS Cairo *Ḥalim miḡāt* 19 the author mentions the first and second *ṭa'akhub* on Friday (fol. 47v). Unfortunately he gives no further information.

drawn using a geometric construction of the kind known as analemma,¹³ or by using tables of coordinates of the intersections of the hour lines with the three shadow traces taken from tables prepared in advance. The only known tables for constructing sundials which predate the time of Ibn al-Šaffār are those of al-Khwārizmī, compiled in early ninth century Baghdad,¹⁴ and displaying the coordinates of the intersections of the hour-lines with the two solstitial traces. Al-Khwārizmī gave values of the shadow length, measured from the foot of the gnomon, and the azimuth, measured from the east-west line, for each hour at both solstices and for a series of terrestrial latitudes, including 38° and 40°. In view of the fact that some of the hour-lines on Ibn al-Šaffār's sundial consist of two segments drawn between each of the shadow-traces for the solstices . . . and that for the equinoxes, it follows that if he used tables, then they must have displayed coordinates for the equinoxes, although these are superfluous since the hour-lines are taken as straight lines. To construct the lines using an analemma one likewise needs only two sets of points. But Ibn al-Šaffār used three. Furthermore, the fact that the segments between the shadow traces at the equinoxes and the summer solstice for the third, fourth, fifth, seventh, and eighth hours are more or less parallel to the meridian indicates the seriousness of his error. The curve for the *zuhr* was probably constructed by joining the three points on the shadow traces which are such that their distance from the gnomon is the meridian shadow increased by the standard one quarter of the length of the gnomon. However, one might think from looking at Ibn al-Šaffār's sundial that the *zuhr* was at about 1½ seasonal hours after midday at the summer solstice and at about 2½ seasonal hours after midday at the winter solstice. In fact, the curve for the *zuhr* should not cross the eighth hour line.¹⁵

The remains of Ibn al-Šaffār's sundial do him little credit. One might have expected something better from one of the leading astronomers of Andalusia, when that province of the Islamic world was close to its cultural zenith. Nevertheless Ibn al-Šaffār's sundial is a better specimen than the two that we shall investigate next.

(b) *The Almería Sundial*

The second sundial is preserved in the Museo Arqueológico de Almería, and is displayed in Plate 3. It has been described by Juan J. de Orús (1956) and Dario Cabanelas (1958).¹⁶ A substantial part of the western half of the sundial is missing, and the maximum dimensions of the remaining portion of the marble slab are 28 × 29 cm.

13. On the analemma see Neugebauer, pp. 214-218 and the references there cited.

14. See note 5 above.

15. Cf. King 2, p. 191.

16. Cf. de Orús, and Cabanelas, pp. 392-394. See also note 18 below.

meridian.¹¹ This hole has been violated by the gnomon to such an extent that its centre is no longer on the meridian. A segment perpendicular to the right edge of the sundial when extended passes through this hole and represents the east-west direction. The three lines which are drawn across the meridian are: closest to the hole, the hyperbola representing the shadow trace at the summer solstice (when shadows are shortest), next, a straight line representing the shadow trace at the equinoxes, and, furthest from the hole, the shadow trace at the winter solstice (when shadows are longest). The lines drawn across these three lines indicate the seasonal hours of day, starting at the first on the right, then the second, third, fourth, and fifth, then the sixth, which is precisely midday because we are dealing with seasonal hours that are one-twelfth divisions of daylight, and then the seventh and eighth. The hour-lines are marked *ākhir al-ūlā*, "end of the first (hour)", *ākhir al-thāniya*, "end of the second (hour)", etc. The curve close to the left hand edge of the sundial indicates the time for the *ḡuhr* prayer. We may presume that the sundial originally bore a curve for the beginning of the *ʿaṣr* prayer as well.

We now investigate the markings more closely, firstly to establish the underlying latitude, and secondly to ascertain the accuracy of the markings. All of the measurements are based on the photograph illustrated in Plate 2. The length of the gnomon is $n = 9\frac{1}{2}$ mm., and the midday shadow at the winter solstice OW is $18\frac{1}{2}$ mm. Thus

$$9\frac{1}{2} \cot (\bar{\varphi} - \epsilon) = 18\frac{1}{2}$$

so that

$$\cot (\bar{\varphi} - \epsilon) = 1.97, \quad \bar{\varphi} - \epsilon \approx 27^\circ \quad \text{and} \quad \varphi + \epsilon \approx 63^\circ$$

But $\epsilon \approx 23.30^\circ$, so that

$$\varphi \approx 39.30^\circ,$$

which is close to the standard medieval Islamic value for the latitude of Cordova 38.30° .¹² The accurate value for Cordova is 37.53° .

A glance at the sundial reveals several defects. Firstly, the equinoctial shadow trace is not a straight line, as it should be. Secondly, the lines for the third and fourth and eighth hours are not straight, as, in a sundial of this size, they should be. These defects are so obvious to anyone with the most modest knowledge of gnomonics, that we may well wonder why Ibn al-Ṣaffār put his name to the sundial. We cannot be sure whether the markings were

11 Cf. Cabanellas, p. 396, where it is suggested that the circle serves no purpose other than decoration.

12. This is easily confirmed by consultation of the computer print-out of medieval Islamic geographical coordinates described in Kennedy-Haddad.

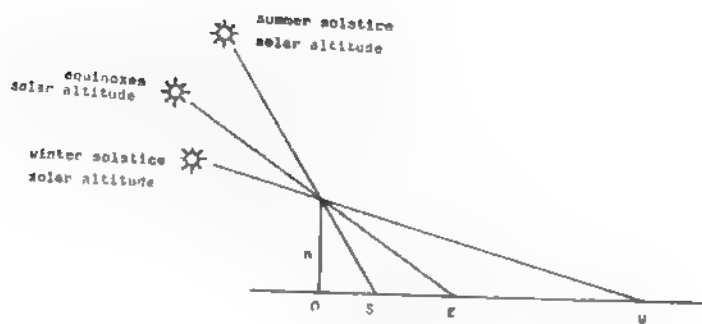


Fig. 1

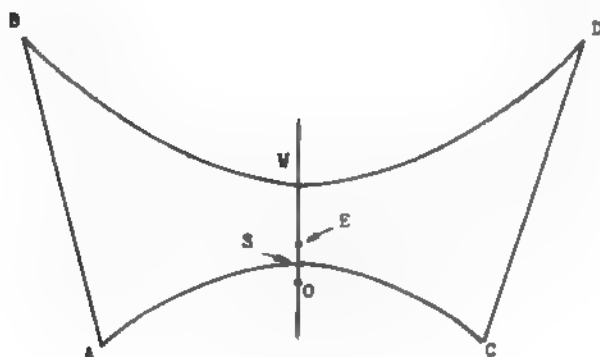


Fig. 2

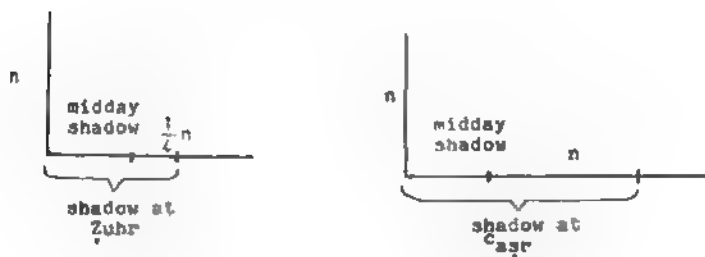


Fig. 3

in Andalusian practice are that the gnomon shadow shall have increased beyond its midday minimum by $\frac{1}{4}n$ and n , respectively (see Fig. 3).⁷

(a) *The Cordova Sundial*

In the Museo Arqueológico Provincial in Cordova there is a fragment of a horizontal sundial, illustrated in Plate 2, which was found in the Camino Viejo de Almodovar in Cordova. It has been published by Samuel de los Santos Jener (1955) and Dario Cabanelas (1958).⁸ The instrument bears the name of Ahmad ibn al-Saffār, an astronomer of some renown who worked in Cordova about the year 1000 A.D.,⁹ and is thus the oldest surviving Islamic sundial, although it has not been previously identified as such.¹⁰

The remains of the Cordova sundial consist of a little more than half of the original instrument. The dimensions of the original sundial were 48 cm. (approx.) \times 34.5 cm. \times 4.5 cm. The inscriptions are in elegant floriated Kufic, and the maker's name appears in the upper right corner. The cardinal directions are marked on the sundial, which is broken just to the left of the meridian, or north-south line. The hole on this line once carried a vertical gnomon, the length of which is indicated by the radius of the circle to the right of the

7. On the times of prayer in Islam see Wiedemann-Frank, A. J. Wensinck's article *Ṣalāt* in *Et.*, and King § For an explanation of the definitions in terms of the increase of the shadow see King 2. Appendix B. A more detailed study on the origin of the definitions of the times of prayer in Islam is in preparation.

8. Cf. de los Santos and Cabanelas, pp. 394-396. See also notes 10 and 11 below.

9. On Ibn al-Saffār see *Mincherr.* p. 131, and the article by B. R. Goldstein in *Et.* III, p. 924, and the references there cited, to which add now Sezgin, V, pp. 356-357, and VI, to appear. Ahmad ibn al-Saffār had a brother Muhammad who was a maker of astrolabes (cf. *Mayer*, p. 75, for details of an instrument made by him in the year 1029).

Ibn al-Saffār was a student of the Andalusian astronomer and mathematician Maslama al-Majrīṭī, author of a revision for Andalusia of the *zīj* (astronomical handbook consisting of text and tables) of the ninth century Baghdad astronomer al-Khwārizmī (on whom see G. Toomer's article in *DSB*). Ibn al-Saffār also compiled a *zīj* based on the methods of the Indian *Zīj al-Sindhind* (Kennedy, no. 17). Only the introduction to Ibn al-Saffār's *zīj* survives, namely, in an Arabic manuscript written in Hebrew characters preserved in the Bibliothèque Nationale in Paris (the tables in this manuscript are not related to Ibn al-Saffār). His only other known work is a treatise on the use of the astrolabe, which was popular amongst later Muslim astronomers and is extant in several copies (the Arabic text of this treatise was published by J. Millas Vallicrosa in 1955), and was also translated into Latin and Hebrew. In his later years Ibn al-Saffār moved from Cordova to Denia, where he died in the year 1035.

10. In de los Santos the name is read Ahmad b. al-Tulb. and in Cabanelas, p. 396 as Ahmad b. al-Sawwār. I agree that the reading *sawwār* is easier to justify than *saffār* (the dot over the middle radical is a scratch), but firstly "*sawwār*" is not attested as a name meaning "diseñador, delineante, pintor", and secondly Ahmad b. al-Saffār was a well-known astronomer of Cordova.

The three sundials are preserved now in three different museums in Spain, and I shall henceforth designate each of the sundials by its present location, namely, Cordova, Almeria, and Granada. All of the sundials are of the horizontal kind designed for a specific latitude and displaying the seasonal hours of day. Such sundials were used already in antiquity,⁴ and are described in the earliest Arabic treatises on sundials.⁵ They are also described in the thirteenth century Andalusian *Libros del Saber* (see Plate I).⁶

Two of the Andalusian sundials are broken, but each of them displays all or parts of three main sets of markings. These are (a) the north-south line and shadow-traces for the solstices and equinoxes; (b) the hour lines for each seasonal hour of daylight from the end of the first hour to the end of the eleventh hour; and (c) the curves for the midday (*zuhr*) and afternoon (*‘aṣr*) prayers. Each sundial was originally fitted with a gnomon erected vertically in a hole in the sundial; in all cases, these gnomons are now missing.

I shall use the following notation freely. The points at which the shadow-traces for the summer solstice, equinoxes, and winter solstice, intersect the north-south line (see Fig. 1) are labelled *S*, *E*, and *W*. The base of the gnomon is *O*, and its length is *n*. The most commonly used length of the gnomon in Islamic sundial theory was 12 units. Clearly, for a locality with latitude ϕ (see Fig. 2):

$OS = n \cot(\bar{\phi} + \epsilon)$; $OE = n \cot \bar{\phi}$; and $OW = n \cot(\bar{\phi} - \epsilon)$, where ϵ is the obliquity of the ecliptic and $\bar{\phi} = 90^\circ - \phi$. For Andalusia $\phi \approx 38^\circ$ and approximately $OW:OS = 7\frac{1}{2}:1$. Also, *E* is roughly at the point of trisection of *SW* closer to *S*, so that approximately $SE:EW = 1:2$. The lines for the first and eleventh hours between the summer shadow-trace and the winter shadow-trace are labelled *AB* and *CD*.

The standard definitions of the times for the *zuhr* and *‘aṣr* prayers

4. See Gibbs, pp. 39-42 and 323-328.

5. See Segin, VI, *passim*. An important aspect of these treatises is the tables of coordinates for marking sundials which some of them contain. I am currently preparing an edition of al-Khwārizmī's sundial tables, and a survey of all later Islamic sundial tables. For a brief introduction see King I, pp. 51-53 and 56.

6. *Libros del Saber*, IV, pp. 1-23. No author is associated with this treatise, which was written especially for Alfonso X because no book on the subject could be found which was "complete in itself" (Procter, p. 18). It is in two parts arranged in 14 and 4 chapters, and deals with the construction and use of a horizontal sundial marked for the seasonal hours (see also Cabanellas, pp. 400-403). The treatise contains tables of the solar declination, and the sine and cotangent functions, but no tables or geometrical procedures for constructing the kind of sundial described in the text. The latter is distinguished from the three Andalusian sundials described in this paper by the inclusion of circles drawn about the gnomon corresponding to the shadows of each 5° of solar altitude, and by the fact that there are no curves for the prayer-times, since these would no longer be of concern to a Christian reader.

Three Sundials from Islamic Andalusia

DAVID A. KING*

In memory of my friend Louis Janin.

In this paper I propose to discuss three sundials from medieval Andalusia.¹ Each of these sundials has been published previously, in the sense that photographs and a list of the Arabic inscriptions have been published,² but in the present study I shall attempt to investigate the markings on the sundials beyond a mere description thereof. These markings cannot be fully explained in terms of our present knowledge of Islamic gnomonics, but I anticipate that the publication of the repertory of Islamic astronomical instruments currently being prepared by A. Brioux and F. Maddison, which will include all known Islamic sundials,³ will serve to revive some interest in a subject which has hardly progressed for several decades. Hence it seems worthwhile to present these sundials anew and to point out the various problems associated with each one.

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1 The research on medieval Islamic science conducted at the American Research Center in Egypt during the years 1972-80 was sponsored mainly by the Smithsonian Institution (1972-80), and also by the National Science Foundation, Washington, D. C. (1973-80) and the Ford Foundation (1976-79). This support is gratefully acknowledged.

The Cordova sundial was brought to my attention by my friend Dr. Lisa Golombek of the Royal Ontario Museum and the University of Toronto. A photograph of the sundial, together with information on its size and provenance, was kindly provided by Sra. Ana Maria Vicent Zaragoza, Director of the Museo Arqueológico Provincial in Cordova. The fact that the sundial had been published and the existence of the Almería and Granada sundials came to my attention during an annual visit to the Sterling Library at Yale University in the spring of 1978. A photograph of the Tunisian sundial from the archives of Mr. Francis Maddison, Curator of the Museum of History of Science, Oxford, was kindly provided by M. Alain Brioux of Paris. A photograph of the Qayrawan sundial was kindly provided by Capt. René Rohr of Strasbourg. Prof. Owen Gingerich of Harvard University kindly obtained for me a microfilm of the *Libros del Saber* from Harvard University Library. Finally, it is a pleasure to record my gratitude to those libraries which have supplied me with microfilms of manuscripts in their collections, including the Egyptian National Library in Cairo, the Biblioteca de El Escorial, the Biblioteca Medicea-Laurenziana in Florence, and the British Library in London.

2. Each of the publications (*de los Santos* on the Cordova dial, *de Orús* on the Almería dial; and *Cabanelas* on all three Andalusian dials) contains errors of interpretation, and none of them points out any of the defects of the dials. However, Cabanelas provided useful physical descriptions of each of the dials and put them in the context of earlier Greek sundials and the treatise on sundials in the *Libros del Saber*.

3. Until now the only general repertory of Islamic sundials has been Mayer.

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| Kennedy | E. S. Kennedy, "A Survey of Islamic Astronomical Tables", <i>Transactions of the American Philosophical Society</i> , N. S., 46:2 (1956), 123-177. |
| Kennedy & Ghanem. | E. S. Kennedy, and I. Ghanem, eds., <i>The Life and Work of Ibn al-Shāṭir an Arab Astronomer of the Fourteenth Century</i> (Aleppo, Institute for the History of Arabic Science, 1976) |
| King 1. | D. A. King, "A Fourteenth Century Tunisian Sundial for Regulating the Times of Muslim Prayer", in <i>Prismata. Festschrift für Willy Hartner</i> , eds. W. G. Saltzer and Y. Maeyama, (Wiesbaden, Franz Steiner Verlag, 1977), pp. 187-202. |
| King 2: | D. A. King, "On the History of Astronomy in Medieval Egypt", <i>Bulletin de l'Institut d'Egypte</i> , 1977. |
| King 3 | D. A. King, "On the Astronomical Tables of the Islamic Middle Ages", <i>Studia Copernicana</i> , vol. 13 (<i>Colloquia Copernicana III</i>) (1975), 37-56. |
| Luckey. | P. Luckey, "Thābit b. Qurra's Buch über die ebenen Sonnenuhren", <i>Quellen und Studien zur Geschichte der Mathematik, Astronomie, und Physik</i> , Abt. B, Bd. 4 (1937-1938), 95-148. |
| Mayer. | L. A. Mayer, <i>Islamic Astrologists and their Works</i> (Geneva, Albert Kneidig, 1956). |
| Michel & Ben-El: | H. Michel, and A. Ben-El, "Un Cadran Solaire remarquable", <i>Ciel et Terre</i> , 81 (1965). |
| Nallino: | C. A. Nallino, <i>al-Battānī sive Albategni Opus Astronomicum</i> , (<i>Pubblicazioni del Reale Osservatorio di Brera in Milano</i> , XL), 3 vols. (Milan and Rome, 1899-1907, reprinted Frankfurt Minerva G. m. b. H., 1969). |
| RCE 1 | Et. Cambe, J. Sauvaget, G. Wiet, etc., <i>Repertoire Chronologique d'Epigraphie Arabe</i> , tome 13. (Le Caire, 1944). |
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Table 3
 Coordonnées des positions respectives sur le cadran Ibn Tūlūn
 (Ombre en mm., azimuts au degré le plus proche)

Heures	Solstice d'été				Solstice d'hiver			
	Côté gauche		Côté droit		Côté gauche		Côté droit	
	Ombre	Azmut	Ombre	Azmut	Ombre	Azmut	Ombre	Azmut
1	185	18° S	187	19° S	275	33° N	272	33° N
2	83	10 S	83	11 S			130	40 N
3	50	4 S	50	4 S	93	49 N	94	48 N
4	28	3 N	28	2 N	73	60 N	73	59 N
5	-		13	19 N	62	74 N	62	73 N
6	5	90 N	5	90 N	58	90 N	57	90 N
ϵ_{afr}			50?	4 S		ϵ_{afr} (original)	102	45 ½ N
						ϵ_{afr} (corrigé)	105	44 ½ N

Equinoxes: Ombre de midi 26, ombre de l' ϵ_{afr} 71 ½, azimut de l' ϵ_{afr} 21 ½°

Table 2

Tables d'al-Maqsi pour un cadran horizontal à la latitude 30°
(MS Istanbul Nurosmaniye 2943, fol. 13v)

Heures	Solstice d'été				Solstice d'hiver			
	Hauteur	Azimuth	Ombre	Hauteur	Azimuth	Ombre	Azimuth	Ombre
1	13;51°	[0] 19;28° [-1] S	48;40 [-1]	9;21°	[0] 34;16°	[0] 72;[58?] ¹ [+1]		
2	28;22	[0] 12;19	[0] S	22;14	[0] 17;54	[0] 42;13	[0] 37;9	[-1]
3	43;[15] ¹ [-1]	5;19 [+6] S	12;45	[0] 25;20	[0] 51;41	[0] 25;21	[0] 25;21	[0]
4	58;20 [-1]	3;1 [-12] N	7;24	[0] 31;13	[-1] 62;56	[+1] 19;48	[+1]	[+1]
5	73;13 [+1]	18;12 [-5] N	3;37	[0] 35;4	[0] 75;57	[+3] 17;6	[+3]	[+1]
6	83;35 [0]	90;0 [0] N	1;21	[0] 36;25	[0] 90;0	[0] 16;16	[0]	[0]
^c <i>ayr</i>	41;58 [+1]	5;51 [-1] S	13;21	[0] 23;0	[0] 48;20	[0] 28;16	[0]	[0]

Equinoxes: Ombre de midi 6;56[0], ombre de l'^c *ayr* 18;56[0], azimuth de l'^c *ayr* 21;28° [0]

1 Le MS Nurosmaniye porte 55 mais le MS Le Caire Dar al-Kutub *niğaz* 955, fol. 9v, porte 15.

2. Nurosmaniye: 18, Le Caire: 13, exact: 57.

Table 1

Tables d'al-Marrākushī pour un cadran horizontal à la latitude 30°
(MS Paris B. N. ar. 2507, fols. 123v and 137r)

Heures	Solstice d'été		Solstice d'hiver	
	Hauteur	Azimut	Hauteur	Azimut
1	13;51° [0]	19;28° [-1] S, 48;40	[-1] 9;21°	[0] 34;14° [-2 N] 72;53 [-4]
2	28;21 [-1]	12;19 [0] S, 22;15	[+1] 17;53	[-1] 42;14 [+1 N] 37;10 [0]
3	43;15 [-1]	5;13 [0] S, 12;45	[0] 25;20	[0] 51;40 [-1 N] 25;21 [0]
4	58;22 [+1]	3;16 [+3] N, 7;24	[0] 31;15	[+1] 62;55 [0 N] 19;48 [+1]
5	73; 8 [-4]	18;12 [-5] N, 3;38	[+1] 35;5	[+1] 75;53 [-1 N] 17;5 [0]
6	83;35 [0]	90;0 [0] N, 1;21	[0] 36;25	[0] 90;0 [0 N] 16;16 [0]
ϵ_{air}	41;58 [+1]	5;52 [0] S, 13;21	[0] 23;0	[0] 48;20 [0 N] 28;16 [0]

Equinoxes: Ombre de midi 6;56 [0], ombre de l' ϵ_{air} 18;17 [devrait être 18;56!],
azimut de l' ϵ_{air} 21;14° [-14] S

un dessin (voir Pl. 5). Ce cadran comporte un demi-cadran à droite qui montre le temps écoulé depuis le lever du soleil (et du même coup le temps qui reste à courir jusqu'à midi et à la prière qui y est associée, le *zuhr*). Les courbes des heures sont dessinées pour chaque dix degrés équinoxiaux et les valeurs sont indiquées sur la courbe du Cancer comme suit: 20°, 30°, . . ., 100° (le maximum pour la latitude 30° est environ 104½°). Le demi-cadran à gauche montre les degrés qui restent jusqu'à l'*ʿaṣr* comme suit: 50°, 40°, 30°, 20°, 10°, puis la courbe de l'*ʿaṣr* même, puis les degrés qui restent jusqu'au coucher du soleil (et à la prière du *maghrib*) comme suit: 50°, 40°, 30°, 20°. Voici donc un cadran bien utile pour la mosquée, qui sert à montrer le temps qui reste à courir jusqu'aux temps des trois prières: *zuhr*, *ʿaṣr*, et *maghrib*.

APPENDICE

Additions et Corrections à Janin & King

1. Nous avons omis de souligner le fait, d'ailleurs évident, que lorsqu'Ibn al-Shāṭir explique qu'il regarde l'extrémité de la boussole par le trou dans le couvercle de la boîte, il ignore la déclinaison magnétique. Un siècle plus tard, aussi que nous l'avons remarqué, al-Wafā'i suggère une correction de 7° pour en tenir compte.

2. Nous préparions notre description et usage du cadran polaire universel dans l'instrument d'Ibn al-Shāṭir, lorsque nous avons eu connaissance d'une illustration et d'une description dans *Michel et Han Eli*, d'un cadran polaire pour une latitude déterminée construit à Acce en 1786-87. Nous reproduisons l'illustration dans la Pl. 6. Notez qu'il n'y a pas de courbe pour l'*ʿaṣr*, on aurait pu en dessiner une pour la latitude locale, mais elle n'aurait pas pu servir pour d'autres latitudes. Il n'est pas exact de dire, avec Michel, que le cadran d'Acce était surtout destiné à régulariser les heures de prières. Nous ne connaissons pas d'autre cadran polaire dans le monde de l'Islam.

3. L'autre instrument décrit par al-Wafā'i, appelé *al-muqawwar* et mentionné p. 217 note 11, est en fait une armille équatoriale comme le *dā'irat al-mu'addil* mais les différentes parties se repètent et peuvent être conservées dans la boîte ronde avec couvercle qui forme la base de l'instrument. Il résulte du traité d'al-Wafā'i sur cet instrument que c'était une production antérieure à celle du *dā'irat al-mu'addil*: il ne mentionne pas, par exemple, la déclinaison magnétique, se contentant de dire que l'aiguille de la boussole a sa direction "près du méridien". Dans un article précédent nous avons comparé le *ṣandūq al-yawāqit* d'Ibn al-Shāṭir avec le *dā'irat al-mu'addil* d'al-Wafā'i: *al-muqawwar* d'al-Wafā'i constitue un échelon intermédiaire de développement et confirme notre impression qu'al-Wafā'i s'était inspiré du *ṣandūq al-yawāqit* d'Ibn al-Shāṭir.

4. À la p. 213 liex *samkarakha* au lieu de *mubkarakha*.

que Marcel avait à sa disposition. les renseignements qui découlent de ces mesures sont assez surprenants.

En général les dessins du cadran que nous avons examinés semblent être assez exactement disposés, mais deux exceptions sont la courbe de l'*ʿaṣr* et le tracé du solstice d'hiver. La branche gauche inférieure de la courbe de l'*ʿaṣr* a été visiblement ajoutée plus tard pour essayer de rectifier la courbe originale de l'*ʿaṣr*. De plus, l'erreur de la courbe originale de l'*ʿaṣr* près du tracé du solstice d'hiver apparaît bien provenir d'une erreur dans la position de l'intersection du dit tracé avec le méridien. Si nous ajoutons la longueur du gnomon à la distance sur le méridien entre le pied du gnomon et le tracé du solstice d'hiver, nous obtenons la distance entre le pied du gnomon et l'intersection de la courbe originale de l'*ʿaṣr* avec le tracé. Celui qui a dessiné la courbe corrigée de l'*ʿaṣr* s'est arrangé pour que l'ombre de l'*ʿaṣr* au solstice d'hiver ait une longueur correcte, mais l'erreur dans le tracé du solstice d'hiver sur le cadran entre la neuvième heure et la onzième, résultant probablement d'une erreur dans la position de la marque de la dixième heure au solstice, rendait impossible d'obtenir en même temps l'azimut correct pour l'*ʿaṣr*. Etant donné que la fonction la plus importante d'un cadran de mosquée est l'indication du temps des prières, on ne peut pas dire que le constructeur de ce cadran ait remporté un plein succès! Peut-être, d'ailleurs, avons nous mis le doigt sur la raison de la destruction de ce cadran, brisé en plusieurs morceaux.

Enfin, nous remarquons que le seul autre exemple d'un cadran fait de deux demi-cadrans superposés que nous connaissons se trouve dans un traité sur la gnomonique par le *muṭaqqit* égyptien Ibn al-Muballabī, écrit au Caire en 829 H. = 1425—26 J. C.^o Ce traité existe dans un beau manuscrit unique conservé à la Bibliothèque de Chester Beatty à Dublin, numéroté 3641 et copié à Alexandrie en 858 H = 1455 J. C. Ibn al-Muballabī commence son traité par un éloge d'al-Maṣī, en ajoutant que le lecteur qui veut en savoir plus que ce qu'il va exposer dans son traité doit se tourner vers le compendium d'al-Marrākushī. Puis Ibn al-Muballabī présente de nouvelles tables (voir Pl. 4) et de nouveaux dessins pour construire les cadrans horizontaux, verticaux, et inclinés, tous calculés pour la latitude du Caire, 30°. Parmi ces textes on trouve des tables pour tracer un cadran à deux moitiés avec

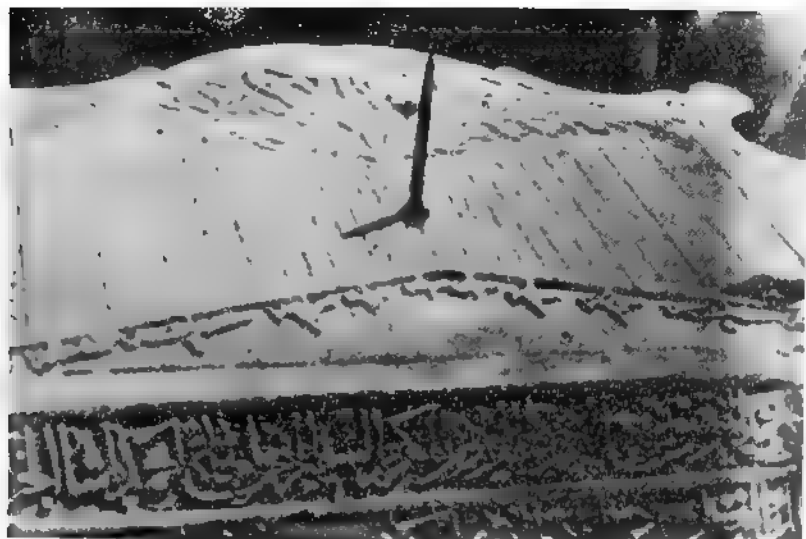
6. Si n est la distance requise en mm, nous avons, du fait que la distance méridienne entre les tracés des deux solstices est 52 mm, et que les ombres solsticiales sont 1:21 et 16:16 unités, que

$$\frac{n + 52}{n} = \frac{16:16}{1:21} \approx 12 \quad ,$$

d'où

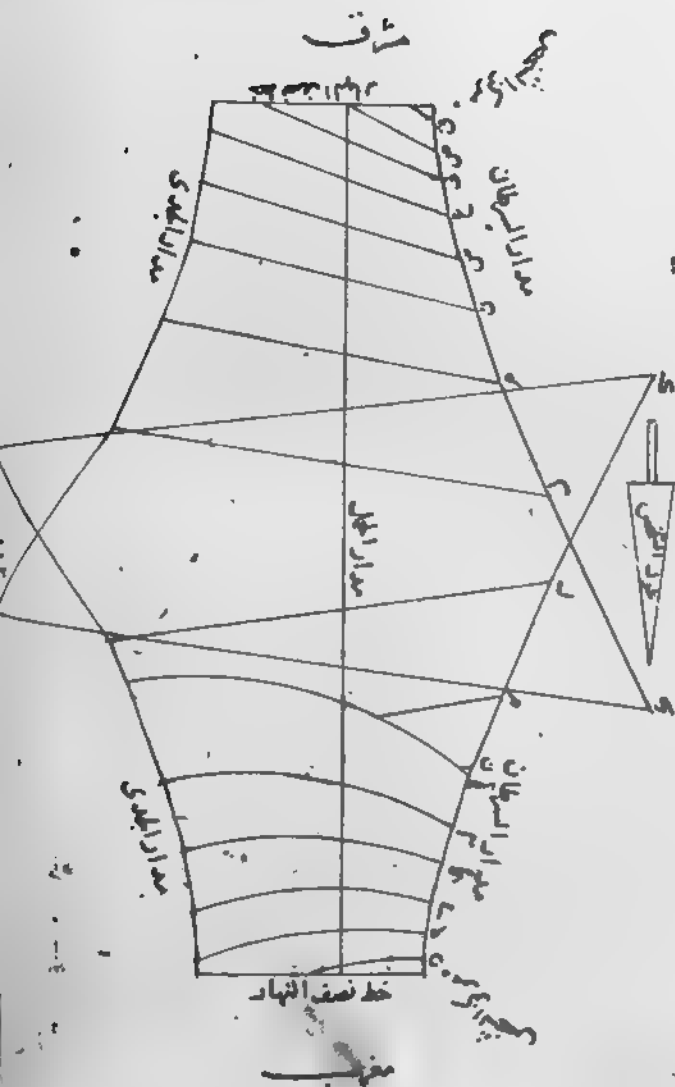
$$n + 52 = 12n \quad \text{et} \quad n \approx 5 \text{ mm.}$$

7. Ibn al-Muballabī n'est mentionné dans aucun travail moderne sur la science islamique et on ne lui connaît aucun autre ouvrage scientifique.



Pl. 6: Le cadran polaire d'Acre.

(photo Abumax)



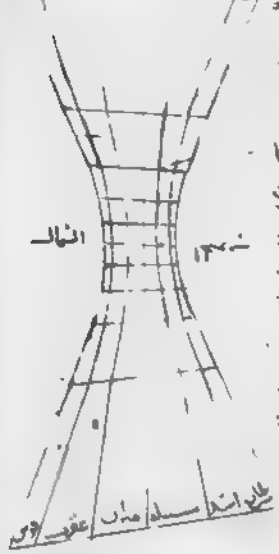
هذه صورة بسيطة الدائر من الفلك مشرقاً متفاضلة عشر درجات

[illegible]

P^{er} 4 Extrait du manuscrit Dublin Chester Beatty no. 2641 (fols. 10^r et 11^r), qui montre les tables avec lesquelles on pourratt dessiner le cadran illustré en Pl. 5. A droite on voit les tables qui donnent la hauteur du soleil, son azimut, et la longueur de l'ombre d'un style de 12 unités, le tout calculé pour chaque 5^e de temps écoulé jusqu'au milieu du jour pour les deux solstices. A gauche on voit les trois mêmes quantités calculées pour chaque 5^e avant l'«*ajir*» pour les deux solstices et les équinoxes.

[illegible]

۲- سحر: الحرام الحذف وقيل ولا يصح ما في قوله عز وجل ولا يصح



که غریب کا مدد و اسامی اللہ عزوجل و البحر الذی یطاف

اولد زجه مسايه با جود زخه نزل الخ طوما وصفاة في خذ الله مور مصطفا اول

لم يرضوا ما جرى ذكرها بعد إلا زاد حال العامة لهم من بعد مجلسه الطل ومحمد طاسع الطل

فانه سلطان كرام الله والحمد لله رب العالمين

علاوة على ذلك، فإنّ دراسة الخرجات العامة في الدول النامية والصاعدة تظهر وجوداً واضحاً

وأضاح على الملازم في خدم الآي وتلقم . حتى يصح خروج الزمر اللواتي أضاحا إلى سطح الجسر

الزهر والورق لخط الحباله الساخه سواها من القمار ومطعم كرا

منهم من السوء في طاعة الله، الباقية معكم، راس النازلة، وزادة الاخر عدل، ووجه العسر الذي

طبع في دار المطبعات العلم في القاهرة في سنة ١٣٠٠ هـ

٥ ولما سافر من مكة إلى مصر، ودرست الصرخة بالصرخة والنداء

P¹ 3 Extrait du manuscrit le Caire Taimûr *riyâdhât* 105 (fol. 137v-138r), du traité du roi Yemûne at-Ashraf, qui montre le dessin d'un cadastre aux heures rempennures pour la latitude de Tair (13.37°), et les tables qui servent à le tracer. On remarque que le pied du gnomon se trouve entre la



INSCRIPTION ET CADRAN SOLAIRE DE LA MOSQUÉE DE TUL LOIN

Pl. 1. Le cadran solaire de la Mosquée d'Ibn Tulûn, reproduit par M. Marcel, et inséré comme illustration dans la *Description de l'Égypte*.

référer à Ibn al-Shāfir ni à aucun autre astronome syrien.

Examinons maintenant les tables d'al-Marrākushī (Pl. 2) et d'al-Maḡsī pour un cadran horizontal donnant les heures temporaires pour la latitude du Caire, retenue pour 30;0° avec une obliquité de 23;35°. Ces deux tables sont reproduites dans les Tableaux 1 et 2⁴ et il apparaît probable qu'elles ont été calculées indépendamment. Les valeurs ont été recalculées avec le calculateur électronique de l'Université Américaine du Caire,⁵ et pour chaque valeur des tables d'origine l'erreur dans le deuxième chiffre sexagésimal, c'est-à-dire dans les minutes, est donnée entre crochets, calculée selon la convention:

$$\text{erreur} = \text{texte} - \text{valeur exacte}$$

Les deux tables sont assez exactement calculées, bien que chacune comporte quelques erreurs qui auraient dû surprendre leurs calculateurs. Néanmoins les erreurs dans les coordonnées de l'*ʿaṣr* chez al-Marrākushī pour les équinoxes sont bien moins graves que celles qui ont produit la branche inférieure droite de la courbe de l'*ʿaṣr* sur notre cadran.

Le Tableau 3 montre les coordonnées correspondant aux positions solsticiales et équinoxiales du cadran d'Ibn Tūlūn, basées sur les mesures prises sur la planche de la *Description de l'Égypte*. Pour obtenir ces coordonnées on a d'abord calculé que les pieds des deux gnomons étaient à une distance d'environ 5 mm. au nord de l'intersection des méridiens et du tracé du solstice d'été.⁶ Si l'on tient compte du caractère fragmentaire du cadran

4. La table d'al-Marrākushī se trouve déjà dans *Sādillat-père*, II, pp. 456 and 493.

5. Le processus trigonométrique pour le calcul de ces tables est le suivant. Nous posons la latitude locale φ , l'obliquité ϵ , la longitude du soleil λ . Nous calculons la déclinaison δ solaire par la formule

$$\sin \delta = \sin \epsilon \sin \lambda,$$

et l'équation du jour d par la formule

$$\sin d = \tan \delta \tan \varphi.$$

Ensuite la longueur d'une heure de jour temporelle t se déduit de la demi-longueur du jour D par la formule

$$t = \frac{D}{6} = \frac{90^\circ + d}{6}$$

La hauteur du soleil h correspondant à un angle horaire égal à un multiple n de cette heure temporelle est alors fournie par la formule

$$\sin h = \sin \delta \sin \varphi + \cos \delta \cos \varphi \cos (nt)$$

et la longueur de l'ombre correspondante s pour un gnomon de longueur 12 est alors

$$s = 12 \cot h.$$

Pour trouver l'azimut α nous utilisons la formule

$$\sin \alpha = \frac{\sin h \sin \varphi - \sin \delta}{\cos h \cos \varphi}$$

Les procédés médiévaux étaient mathématiquement équivalents aux procédés ci-dessus. Ils étaient déjà connus des astronomes musulmans au début du neuvième siècle, venant de sources indiennes où ils étaient déduits des projections orthogonales de la sphère céleste. Étant donné que ces déductions n'exigent aucune connaissance de trigonométrie sphérique, il est regrettable que bien des auteurs modernes pensent que les anciens astronomes musulmans qui ont utilisé ces formules devaient nécessairement connaître la formule du cosinus de la trigonométrie sphérique (voir, par exemple, tout récemment, *Saggin*, V, pp. 35 et 261).

Moyen Age aussi comme la latitude du milieu de 4^e climat.⁷

On ne peut pas encore tracer le développement des tables islamiques depuis l'époque Abbasside jusqu'à l'époque d'al-Marrākushī, d'al-Maḡsī et du cadran Ibn Tūlūn, mais les matériaux ne manquent pas pour les recherches futures. Il existe enfin des douzaines de manuscrits arabes et turcs dont la plupart sont de provenance égyptienne, syrienne et turque, qui traitent de la gnomonique et présentent des tables, mais qui n'ont encore jamais été étudiés.⁸ (Curieusement on ne trouve presque rien en langue persane.) Toutes les tables qu'on trouve dans ces traités sur la gnomonique représentent une tradition islamique consistant à préparer des tables presque pour le seul plaisir de préparer des tables! Il est déjà évident dans leurs compilations sur d'autres chapitres de l'astronomie que les astronomes musulmans avaient une véritable passion pour le calcul des tables.⁹

IV. Analyse des dessins du cadran d'Ibn Tūlūn

Ni les tables d'al-Marrākushī, ni celles d'al-Maḡsī ne donnent les coordonnées pour chaque signe du zodiaque, telles qu'elles auraient été nécessaires pour construire le cadran d'Ibn Tūlūn. De plus nous n'avons pas d'autres tables égyptiennes de cadrans solaires remontant au treizième siècle ou aux siècles précédents. En fait les seules tables connues de cadrans solaires islamiques remontant au treizième siècle et qui donnent les coordonnées pour chaque signe, sont celles qui ont été établies pour différentes latitudes dans le Yémen et le Hedjaz par le Sultan du Yémen al-Ashraf, dans son traité sur l'astrolabe, le cadran horizontal et la boussole magnétique, écrit aux environs de 1295.¹ Le Sultan al-Ashraf connaissait l'ouvrage d'al-Marrākushī écrit à peine quinze ans plus tôt. Un extrait de ses tables de cadrans, montrant des tables calculées expressément pour la latitude de Taiz retenue pour 13;37°, est reproduit dans Pl. 3. On ne connaît pas de tables pour cadrans aussi détaillées depuis le quatorzième siècle, bien que le cadran d'Ibn al-Shāṭir construit pour la Mosquée Umayyade de Damas porte le tracé des ombres pour chaque signe du zodiaque,² et qu'Ibn al-Shāṭir ait très probablement construit son cadran en utilisant des tables qu'il avait préparées à l'avance. L'astronome syrien du quinzième siècle al-Tizīnī a dressé un jeu détaillé de tables de cadrans et présenté son travail comme une extension du traité d'al-Maḡsī,³ sans se

7. Voir *Nellina*, II, pp. 188 et 295-296.

8. Une exception est le traité (avec tables) de Sibt al-Māridīnī (*Suter*, no. 445) qui a été étudié dans *Schoy* 2.

9. Voir *Kennedy* sur les manuels astronomiques appelés *zījes* et *Kīng* 3, spécialement pp. 51-53 et 56, où l'on traite des tables pour construire les cadrans solaires.

1. Sur le Sultan al-Ashraf voir *Suter*, no. 394. Son traité ne trouve dans le MS Le Caire Taymūr riyyāda 105 (149 fols., ca. 695H) et il paraît qu'il y en a une autre copie à Téhéran. Une table qui donne la hauteur l'azimut du soleil pour chaque heure temporaire et chaque signe du zodiaque, calculée pour la latitude du Caire, se trouve dans la traite sur les cadrans du célèbre Ibn al-Rayṭham (*f.l.* le Caire, c. 1025 J. C.), dont nous avons examiné le MS Teheran Majlis-i-Shūrā 39341.1 (11 fols., ca. 1000H). Dans ce manuscrit tous les chiffres manquent dans la table, et nous n'avons pas eu l'occasion de consulter d'autres manuscrits de cette œuvre.

2. Cf. l'illustration dans l'étude citée dans la note 3 de la Section 1.

3. Sur al-Tizīnī voir *Suter*, no. 450. Ses tables se trouvent dans le MS Vatican Borg. 105,3 (fols. 20r-38v, ca. 900H), texte apparemment unique.

française par J.-J. Sédillot,² toute la théorie mathématique et en outre des tables pour construire les cadrans horizontaux, verticaux, et inclinés à la fois sur le méridien et sur le premier vertical. Al-Marrākushī donne aussi des tables pour construire ces cadrans à la latitude du Caire, 30°, où il travaillait quelques années avant la construction du cadran Ibn Tūlūn, car il a daté son traité de 1280 J. C.³ Voir en Pl. 2 ses tables et son dessin pour un cadran horizontal préparé pour cette latitude.

Il y a un autre traité égyptien sur les cadrans qui date de la même époque que celui d'al-Marrākushī et qui n'avait jamais été étudié jusqu'à il y a quelques années. Ce nouveau traité qui a été préparé par l'astronome égyptien al-Maqsī en 1277 J. C., soit un peu avant le traité d'al-Marrākushī, contient plus de cent tables pour construire les cadrans à la latitude du Caire, 30°.⁴ Ce qui rend les tables d'al-Maqsī plus complètes que celles d'al-Marrākushī, c'est qu'il calcule une table pour les cadrans verticaux inclinés sur le méridien pour chaque degré de l'inclinaison. Où est-ce qu'on doit chercher l'origine de ces tables Islamiques pour les cadrans?

Il a été découvert en 1974 un traité sur les cadrans attribué à al-Khwārizmī (fl. Bagdad, ca. 830 J. C.).⁵ Ce traité existe dans un manuscrit précieux à Istanbul; il consiste en une courte introduction et en plusieurs tables qui donnent pour douze latitudes différentes entre 0° et 40° la hauteur du soleil, son azimut et la longueur de l'ombre d'un style de 12 unités pour chaque heure temporaire. Il ya des tables additionnelles pour les latitudes de Samarra et Bagdad, et la valeur de l'obliquité employée est 23;51° (employée par al-Khwārizmī dans ses tables astronomiques). En 1976 quelques unes de ces tables ont été trouvées ajoutées au traité sur les astrolabes extraordinaires d'al-Sijzī (fl. Iran, ca. 950 J. C.), conservé dans un autre manuscrit précieux à Istanbul.⁶ D'autres tables de cette sorte existent dans les sources manuscrites. Dans le manuscrit unique du texte arabe du manuel astronomique (zīj) de l'astronome Syrien al-Battānī (fl. Raqqa, environ 910 J. C.), C. A. Nallino, qui a publié ce zīj, a trouvé, parmi quelques tables qui ne doivent pas appartenir au travail original d'al-Battānī, deux petites tables qui donnent la hauteur du soleil et son azimut pour chaque heure temporaire, calculés pour la latitude 36°, employée par al-Battānī pour Raqqa et acceptée au

2. Sédillot-père présente une traduction de la première moitié du traité dans lequel on trouve une discussion de la gnomonique. Sédillot-fils offre un sommaire assez mal présenté de la deuxième moitié du traité.

3. Voir Sédillot-père, pp. 136-137 et 276. J.-J. Sédillot a faussement daté al-Marrākushī à 1230 J. C. (voir Sédillot père, I, pp. 13-14) et n'a nulle part mentionné qu'il travaillait au Caire.

4. Sur al-Maqsī voir *Subur*, no. 383.

5. Sur al-Khwārizmī voir l'article de G. J. Toomer dans DSB. Son traité sur les cadrans se trouve dans MS Istanbul Aya Sofia 4830, fol. 231v-235r, copié 626H/1228-29 à Damas.

6. Sur ce traité voir Seagin, V, p. 334, no. 34.

une deuxième courbe de l'*ʿasr* fut tracée à sa gauche. C'est nettement le cas pour les déclinaisons septentrionales (partie inférieure de la courbe); pour les déclinaisons méridionales, il est impossible de distinguer entre les deux branches. Notre hypothèse se base sur le fait que la branche inférieure droite de la courbe de l'*ʿasr* est effectivement fautive et que la branche inférieure gauche est plus correctement disposée (voir Section IV).

Bien qu'il soit beaucoup plus récent (696 H = 1296 J. C.) que la mosquée à laquelle il était destiné (elle fut construite en 259 H = 872 J. C.), ce cadran est le plus ancien des cadrans solaires musulmans du Caire qu'on connaît aujourd'hui. Son dessin, nous l'avons vu, est original. La gravure est d'une exécution parfaite. Ses inscriptions sont d'une écriture très rare: elles sont en caractères karmatiques de la forme la plus élégante; les points diacritiques y sont fidèlement indiqués. A tous ces titres et bien que nous ne le connaissions que par une reproduction, heureusement très exacte, le cadran solaire qui ornait jadis la Mosquée d'Ibn Tūlūn était une pièce splendide, au moins à première vue.

III. Sur les tables employées par les astronomes arabes pour la construction des cadrans

En considérant les nombreux traités sur les cadrans écrits par des savants arabes aux premiers siècles de l'islam et la pléthore de tels traités (écrits principalement en Egypte, Syrie, et Turquie) dans les six derniers siècles, on voit que le petit nombre des cadrans qui subsistent ne représente point l'intensité de l'activité musulmane dans ce domaine. On connaît l'existence de traités sur les cadrans, dont la plupart sont perdus, préparés par plusieurs astronomes arabes dès l'époque Abbasside (spécialement au neuvième siècle).

Le plus complet parmi les documents les plus anciens qui nous sont connus à l'heure actuelle est une remarquable étude sur les cadrans plans qui émane de Thābit b. Qurra, philosophe, médecin, mathématicien, et traducteur, (f. Baghdad, ca. 900 J. C.). Ce traité, publié et traduit par K. Garbers et analysé par P. Luckey,¹ expose la théorie géométrique de toutes les sortes de cadrans plats, d'une manière très rationnelle et très détaillée, précisant les formules diverses utilisées pour le calcul et la construction de ces cadrans, qu'ils soient horizontaux, verticaux, méridionaux, ou déclinants, orientaux ou occidentaux, ou inclinés et déclinants. Mais ce traité ne contient pas de tables. On trouve aussi dans le compendium de l'astronome arabe du treizième siècle Abū 'Alī al-Marrākushī et dans la moitié qui a été publiée en traduction

1. Voir Garbers et Luckey. Une autre très importante étude sur la gnomonique arabe est la thèse de P. Luckey citée dans Seagin, V, p. 294.

n'a rien à faire avec un tel cadran, nous pensons qu'il faut lire: *tāl al-miqyās*, c'est-à-dire, "longueur du style", ou bien, *tāl al-miqyāsayn*, c'est-à-dire, "longueur des deux styles". Nous croyons de plus qu'à côté de cette inscription on trouvait jadis un trait de la même longueur, qui manque sur le dessin de Marcel à cause des fractures du cadran.

Les 4 points cardinaux sont marqués: Nord A, Sud E, Est C, Ouest D. Les 2 styles identiques et perpendiculaires à la table étaient placés au sud de la petite échelle ouvrant chaque moitié, ils avaient leur pied en des points qui n'ont pu être relevés, car les styles avaient été arrachés en même temps qu'avaient été cassées les parties correspondantes de la dalle.

Chaque moitié du cadran comporte les lignes des signes: sur la partie Est sont inscrites la droite des équinoxes (Balance 7) et les hyperboles d'entrées dans les signes (Ecrevisse 4, Lion 5, Vierge 6, Scorpion 8, Sagittaire 9, Capricorne 10). Sur la partie Ouest sont également inscrites la droite des équinoxes (Bélier 1) et les hyperboles d'entrées (Taureau 2, Gémeaux 3, Ecrevisse 4, Capricorne 10, Verseau 11, Poissons 12).

Les heures marquées sont, selon l'usage ancien, les heures "temporaires", qui représentent la douzième partie de la durée du jour; les "heures" d'été sont ainsi plus longues que les "heures" des équinoxes (heures astronomiques), elles-mêmes plus longues que les "heures" d'hiver. Elles sont indiquées par des droites plus ou moins inclinées et qui sont numérotées, du matin au soir: la première I (il faut comprendre fin de la première heure), la deuxième II. . . , la sixième VI (midi), la septième VII. . . la onzième XI. Les heures du lever et du coucher du soleil ne peuvent pas être indiquées, le rayon horizontal du soleil rejetant alors à l'infini l'ombre des styles.

Entre la 9^e et la 10^e heure, sur la moitié Ouest du cadran l'inscription *qaws al-'aṣr*, c'est à dire, "courbe de l'-'aṣr" se réfère à l'heure à laquelle, selon la date, doit être récitée la prière de l'-'aṣr, une des cinq prières obligatoires de l'Islam. D'après l'opinion dominante, l'heure de l'-'aṣr intervient dans l'après-midi, lorsque l'ombre du style est égale à son ombre méridienne augmentée de la longueur du style.

Afin de prévenir le fidèle que l'heure de l'-'aṣr approche, une plage sans gravure est ménagée sur la partie ouest du cadran, à partir de la droite de la 9^e heure. Il est alors plus facile de voir exactement où se trouve la pointe de l'ombre et d'apprécier le temps restant à courir jusqu'à l'-'aṣr. Mais en regardant de près la courbe de l'-'aṣr on constate qu'elle paraît avoir été dessinée en double, très nettement dans sa moitié nord, moins nettement dans sa moitié sud; quelle courbe faut-il retenir?

La raison de cette double courbe de l'-'aṣr semble être que la courbe originale de l'-'aṣr, qui borde l'espace libre, s'est révélée fautive et qu'alors

M. Marcel ont été rapportées d'Égypte et le dessin du cadran solaire qu'elles représentent se trouve reproduit dans l'*Atlas de la Description de l'Égypte*, cet ensemble monumental contenant les rapports de tous les savants chargés de mission et dont on peut dire qu'il a "lancé" l'égyptologie.

Car il s'agit bien d'un cadran solaire, comme le laissent supposer les inscriptions. A première vue, la complexité (Pl. 1) est grande: deux gerbes de 7 branches, maintenues par des sortes de liens, partent des deux côtés de la dalle et s'élancent l'une vers l'autre en s'entrecroisant; partout des inscriptions qui semblent se mélanger et dont il faut retrouver l'application.

Mais pour qui a l'habitude des cadrans solaires musulmans, il apparaît bientôt que le dessin représente en fait deux moitiés d'un seul cadran, imbriquées l'une dans l'autre. Si l'on fait glisser par exemple la gerbe de droite vers la gauche jusqu'à ce que coïncident les deux échelles les plus petites (ou inversement la gerbe de gauche vers la droite, etc.), on reconstitue le dessin connu d'un cadran solaire horizontal ordinaire (Pls. 2 et 3). Alors que chaque moitié du cadran avait son style particulier, la translation ci-dessus effectuée a fait coïncider les deux styles en un seul, qui gouverne l'ensemble du cadran reconstitué.

Pourquoi l'auteur de ce cadran a-t-il adopté la complication des deux demi-cadrans? Il faut d'abord reconnaître que ce dessin, avec ses courbes, droites et inscriptions enchevêtrées, mais disposées selon un plan facile à retrouver, répond bien à la recherche géométrique et ornementale chère aux dessinateurs musulmans. La conception de ce dessin semble d'ailleurs être originale, car nous ne connaissons qu'un autre exemple d'une représentation analogue (voir ci-dessous). En outre le procédé retenu permet de réduire considérablement l'encombrement du cadran.

L'inscription gravée sur le bord inférieur de la dalle indique:

(٩) جعل هذه الساعات بالجمادى الح [ح] .. (٩) [١١] محرووب

باحمد بن طولون تمده الله برحمته في سنة ٦٩٦

c'est-à-dire:

... (?) pour faire (?) ces heures dans la mosquée

... (?) connue par (le nom de) Aḥmad ibn Ṭulūn que Dieu le protège avec Sa grace - dans (?) l'an 696H (= 1296-97 J. C.)

Dans le coin droit supérieur se trouve une autre inscription qui ne se laisse pas très bien lire. Marcel et Sédillot ont cru y lire: *lūl al-Miṣrayn n-h*, c'est à dire, "longitude des deux Murs: 55°". Considérant que la longitude

premier auteur commence par une description du cadran (Section II) et le deuxième continue par une discussion des méthodes employées par les astronomes musulmans pour construire les cadrans solaires (Section III), et une analyse mathématique des dessins du cadran de la Mosquée d'Ibn Tūlūn comparés avec les tables préparées par les astronomes égyptiens à l'époque Mamelouke (Section IV).

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II. Historique et description du cadran

Décidée en 1798 par le gouvernement du Directoire, l'expédition d'Egypte comportait, outre les moyens militaires placés sous le commandement du général Bonaparte, un nombre important de savants et de techniciens appartenant aux disciplines les plus diverses, qui recevaient la mission de se consacrer à l'étude de l'Egypte et de sa civilisation. Parmi les bénéficiaires de cette initiative se trouvait M. J. J. Marcel, ancien directeur de l'imprimerie royale, grand spécialiste des langues orientales et de leurs écritures.

Dès son arrivée au Caire, M. Marcel se mit à dessiner et à reproduire toutes les inscriptions en langue arabe qu'il put relever sur les monuments, principalement sur les mosquées, écoles et tombeaux.

A la mosquée d'Ibn Tūlūn, l'une des plus anciennes du Caire, il découvrit, dans un pan de mur du minaret attenant à la mosquée, plusieurs fragments brisés d'une dalle de pierre, qui comportaient de nombreuses lignes, courbes et inscriptions gravées. Il rassembla aussitôt ces fragments qui reconstituèrent, à part quelques manquants peu importants, une dalle de 69 cm, sur 53 cm, laquelle faisait apparaître un quadrillage complexe mais harmonieux. M. Marcel s'empressa d'en tirer plusieurs exemplaires par les procédés typographiques, comptant bien emporter plus tard les fragments eux-mêmes; mais... dès le lendemain matin, ils avaient disparu!... enlevés par quelqu'un qui avait pensé trouver là des objets de valeur, à en juger par les soins dont les entouraient des Français... Heureusement, les empreintes relevées par

Le Cadran Solaire de la Mosquée d'Ibn Ṭulūn au Caire

L. JANIN[†] ET D. A. KING*

I. Introduction

Depuis les recherches de Carl Schoy aux environs de 1920 sur la gnomonique arabe¹ les cadrans solaires musulmans ont été presque totalement ignorés par les historiens des sciences. Ce qui manque évidemment pour la documentation fondamentale sur la gnomonique arabe, ce sont des reproductions et des descriptions détaillées des plus importants cadrans solaires arabes.² L'un de nous a publié en 1972 une description d'un cadran magnétique du célèbre astronome Syrien du quatorzième siècle Ibn al-Shāṭir, cadran qui n'avait jamais été décrit dans la littérature moderne, bien qu'il soit sans doute le plus splendide de tous les cadrans arabes connus.³ L'autre signataire a préparé plus récemment une description d'un cadran tunisien du quatorzième siècle qui a une importance spéciale pour notre connaissance des origines des définitions des prières musulmanes.⁴ Le cadran que nous présentons ici, qui ornait jadis la Mosquée d'Ibn Ṭulūn au Caire,⁵ n'existe plus, mais il a été l'objet d'une très fidèle reproduction, parue dans la célèbre *Description de l'Égypte* préparée par les savants qui accompagnaient Bouaparte en Égypte.⁶ De son côté L.A.M. Sédillot en a donné une description dans son "Mémoire sur les instruments astronomiques des Arabes" d'après le traité de l'astronome Abū 'Alī al-Marrākushī, qui travaillait au Caire à la même époque que le constructeur du cadran de la Mosquée d'Ibn Ṭulūn.⁷ Nous considérons qu'il est intéressant de présenter à nouveau ce beau cadran à la lumière des plus récentes recherches sur l'histoire de l'astronomie en Égypte médiévale.⁸ Le

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1. Voir Schoy 1 et 2, et aussi Notes 1 et 2 à Section III.

2. Plusieurs des cadrans solaires musulmans qu'on connaît sont indiqués dans Meyer. On s'attend à ce que la nouvelle édition que préparent M. Alain Brieux de Paris et Mr. Francis Maddison d'Oxford contiendra assez de nouvelles informations sur les cadrans pour susciter un renouveau d'intérêt sur ce sujet.

3. Janin, reproduit en Kennedy-Chanem, pp. 107-121.

4. King 1.

5. Voir Wies, pls. 2-5 et pp. 100-101.

6. *Description de l'Égypte, État moderne*, planches, tome II, planche c, et Sédillot-fils, pp. 25-26 et 56-58. Pour la documentation de l'inscription voir RCEA, no. 5023 à p. 157.

7. Voir Sédillot-père, II, Pl. XVI, fig. B6.

8. Voir King 2 et les références citées.

We may well doubt that much would ever have come from Hunter's friend. Even more dubious is Tod's famous epitaph of Jayasimha himself:⁹⁰ "Three of his wives and several concubines ascended his funeral pyre, on which science expired with him." The "science" he supported never had a chance to develop in Sanskrit because no Indians were ever trained to utilize the observatories or the translations in a constructive manner, and because, whatever the results of Jayasimha's own observations may have been, they were not published in Sanskrit.

We have seen, therefore, that though a few elements of Islamic astronomy were adapted by Indian astronomers before the Moghul period, they were not allowed to affect in any way the structure of the traditional science. Moreover, though efforts were made to introduce various of the works emanating from the School of Samarkand to Sanskrit-reading astronomers in the seventeenth century, the translations met with hostility on the part of some, indifference from most, and, at best, an attempt to Indianize them on the part of a few; but these translations and adaptations contained nothing that would instruct the Indians regarding the reason for the claimed superiority of Islamic astronomy, which was its methodology involving both a reliance on carefully planned and executed observations and a concern with the cinematics of the planetary models. Finally Jayasimha's activities, while they resulted in Sanskrit translations of the *Almagest* and a few other works that could have taught this methodology to the Indians, were apparently completely ineffective; his original works in Sanskrit were not innovative, the translations themselves were ambiguous, and the main contribution of his school to astronomy, the *Zīj-i Muḥammad Shāhi* was addressed to a Persian rather than to a Sanskrit audience. Nityānanda, Kamalākara, Jayasimha and others may have recognized the superiority of Islamic over Indian astronomy, but they failed to find a way to persuade other Indian scientists of this fact, in part, I believe, because they did not themselves perceive wherein the superiority lay.

90. J. Tod, *Annals and Antiquities of Rajasthan* (repr. Oxford, 1928): vol. 3, p. 1356

For he did, with his Persian experts, construct those five famous observatories. Jagannātha mentions these observatories and some of the results obtained at them, and some obtained by other astronomers at other observatories.⁸⁶ From this passage and from the *Zīj-i Muhammad Shāhī* produced in the name of Jayasimha probably by Khayr Allāh Khān⁸⁷ we know that Jayasimha intended to follow the traditional method of Islamic astronomy in correcting astronomical parameters by careful observation, and that he hoped to improve the Islamic technique by simultaneously observing the same phenomena from five different localities. Though Jagannātha refers to some minor corrections to parameters like the obliquity of the ecliptic, it appears unlikely that the tables in the *Zīj-i Muhammad Shāhī* are very different from those in the *Zīj* of Ulugh Beg; but no detailed study of Jayasimha's *zīj* has yet been made, so that we cannot decisively deny real significance to his work. However, the description of them given by Hunter in 1797⁸⁸ makes it clear that the structure of the tables is entirely Islamic. We do have for comparison, in Sanskrit, two works attributed to Jayasimha: a *Jayavinodasārīnī* written in 1735, which contains tables for constructing the traditional Indian calendars, and a *Yantrarājaraṇā*, a conventional Sanskrit treatise on the astrolabe. Neither work shows any trace of a new approach to astronomy. Moreover, other Sanskrit astronomical works written in Rājasthān and elsewhere in northern India in the eighteenth century seem not to have been influenced by Jayasimha. In fact, it seems probable that Khayr Allāh Khān was the sole designer of this ambitious project, though Jayasimha supported it enthusiastically and contributed to it financially if not to any great extent intellectually, the *Zīj-i Muhammad Shāhī* was never even translated into Sanskrit as had been the *Almagest*. And the translation of the *Almagest*, though extant in some two dozen complete or fragmentary copies, does not seem to have been used at all by those who composed treatises on astronomy in Sanskrit in the late eighteenth and nineteenth centuries.

Hunter, however, claims to have met at Ujjayini the grandson of one of Jayasimha's assistants whom he believed to be capable of carrying on the tradition because, while trained in traditional Indian astronomy, he possessed manuscripts of the *Siddhāntasamrēt* and of a Sanskrit translation of Napier's logarithms, and he acknowledged the superiority of European science. To Hunter's regret, this paṇḍita soon died, "and with him the genius of Jayasimha became extinct".⁸⁹

86. *Siddhāntasamrēt*, vol. 2, pp. 1162-1165.

87. Storey, pp. 93-95.

88. W. Hunter, "Some Account of the Astronomical Labours of Jayasimha, Rājā of Amhera, or Jayanagar", *AR* 5 (1797), 177-211, esp. 205-209.

89. *Ibid.*, 210.

and then gives Sanskrit equivalents or explanations of them. In doing this the translator demonstrates his knowledge of the traditional Sanskrit terminology in geometry and in astronomy. From time to time either he, or more probably the person who computed the longitude of the solar apogee in 1765, adds Indian material; thus the *Sūryasiddhānta* is wrongly mentioned as using 22/7 as a value of π ,⁷⁹ and the Indian measurements *angula* and *yava* are added to the usual Persian *farsang*, *mil*, and *gaz*.⁸⁰ But otherwise this is a straightforward translation of an introductory manual of astronomy through which a Sanskrit reader could learn the elements of late Islamic astronomy, but nothing about its methodology.

The most conscientious effort, however, to make Islamic astronomy and its methodology available in Sanskrit was that of Savāi Jayasīṃha of Jayapura in the early eighteenth century. Unfortunately, I have not yet had access to the unique manuscript, in the Mahārāja's Museum at Jayapura (no. 46), of Nayanasukhopādhyāya's translation of Naṣīr al-Dīn's *Tadhkira* with the commentary of al-Barjandī;⁸¹ it would indeed be fascinating to examine it and to discover in what form the "improvements" to the Ptolemaic planetary models devised in Marāgha were transmitted to eighteenth century India. But Jagannātha's translation of Naṣīr al-Dīn's version of the *Almagest*, the *Siddhāntasamrāt*, has been published, though not critically edited; from this it is apparent that Jagannātha also had access, presumably through the earlier Sanskrit translations used by Munisvara, Kamalākara, and Nityānanda, to at least some of the views of Ulugh Beg and of his colleague, Jāmshīd al-Kāshī.⁸² For, after the thirteenth and last book of the *Almagest*, he adds a supplement which includes a *vantrāthyāya*, in which he describes the instruments that Jayasīṃha had set up in his observatories in imitation of those installed by Ulugh Beg at Samarcand,⁸³ and an explanation of Ulugh Beg's and al-Kāshī's derivations of sines.⁸⁴ And this is followed by a series of notes on how to deal with traditional aspects of Indian astronomy that are not directly touched on by Ptolemy or that are treated in a different manner by Ptolemy but not, in Jagannātha's opinion, fully enough. He even tacks on at the end a description of the *Sūryasiddhānta*'s planetary theory, presented in the traditional style.⁸⁵ The ambiguity towards scientific method implied by the inclusion of this material in Jagannātha's work is characteristic of Jayasīṃha's approach to astronomy.

79. *Hayatigrantha*, p. 16.

80. *Hayatigrantha*, p. 137.

81. CESS A4.

82. Storey, pp. 72-73.

83. *Siddhāntasamrāt*, vol. 2, pp. 1031-1048.

84. *Siddhāntasamrāt*, vol. 2, pp. 1048-1085.

85. *Siddhāntasamrāt*, vol. 2, pp. 1165 sqq.

and it computes the longitude of the sun's apogee "at the present time" for A. H. 1178, which began on 1 July 1764.⁷² These conclusions are rendered doubtful, however, by the fact that both the references to Kāshī and the computation of A. H. 1178 are omitted by Nīgeṣa, and are therefore likely to be interpolations in the other two manuscripts. This doubt is strengthened to a certainty by the existence of a manuscript of the *Hayatagrantha* copied by Tīkārāma Jyotiṣī in 1730 in the Maḥārāja's Museum in Jayapura (no. 24), and the recording in 1875 of another in Oudh that was copied in 1694.

The *Hayatagrantha*, therefore, was probably written in the seventeenth century, but on the basis of a Persian work different from that available to Nityānanda in 1639. For the *Hayatagrantha*'s parameters for its planetary models, which are completely Islamic, differ from those of Romaka as presented in the *Siddhāntarāja*. The *Hayatagrantha* refers by name to 'Ala' al-Dīn 'Alī al-Qūshjī (allāma kausajī nāma ulūkavegasya guruputra) for his determination by "our observation" (*asmādrasada*) of the obliquity of the ecliptic,⁷³ and for the use of sunset epoch in Arabia (*arabadesa*),⁷⁴ and it mentions "our observation" (*asmābhīr vedhana rasadaḥ*) of the longitude of the solar apogee in Muḥarram 841 A. H., which is July 1437.⁷⁵ This suggests that the Persian original of the *Hayatagrantha* is the *Risālah dar hay'at* or *Fārsī hay'at* composed by al-Qūshjī⁷⁶ at Istanbul and dedicated to the Ottoman Sulṭān Muḥammad ibn Murād (1451-1481), the conqueror of Byzantium; the work was known in Mughal India as the commentary by Muṣliḥ al-Dīn Muḥammad al-Anṣārī and was dedicated to the Emperor Humāyūn (1530-1556). The arrangement of the two texts supports this hypothesis; each contains an introductory section in two parts, two main sections (divided into six and eleven *bābs* respectively in Persian, into four and ten in Sanskrit), and a supplement. I have not been able as yet to examine a copy of the Persian original in order to test this hypothesis. But the fact that the section on chronology in the *Hayatagrantha*⁷⁷ is a revision of that in Ulugh Beg's *Zīj*⁷⁸ confirms the suggestion that the former represents a product of the school of Samarqand.

I do not wish now to go into the details of the *Hayatagrantha*. It should suffice to state that it consistently transliterates the Persian technical terms,

72. *Hayatagrantha*, p. 69.

73. *Hayatagrantha*, p. 24.

74. *Hayatagrantha*, p. 128.

75. *Hayatagrantha*, p. 69.

76. Storey, pp. 75-77.

77. *Hayatagrantha*, pp. 128-133.

78. L. P. E. A. Sédillot *Prolegomènes des tables astronomiques d'Oloug-bek* (Paris, 1853), pp. 7-28.

al-Rūmī) of computing the sine of 1° and even of $1'$.⁶⁷

Unfortunately, the Wellcome Institute's manuscript breaks off in the midst of Nityānanda's descriptions of the Islamic planetary models so that I do not know the extent to which the rest of his work is indebted to Muslim astronomy. But a sufficient portion of the *Siddhāntarāja* has been investigated to show that his planetary system is completely Islamic, though some of its elements are reworked to fit into a traditional Indian mode of expression. But, despite some assertions (not uncommon in classical Sanskrit texts on astronomy) that the Romaka computations lead to results closer to observed positions than do the Sūryasiddhānta's or Brahmagupta's, Nityānanda shows no understanding of the role of observations in improving the models of celestial motions devised by astronomers or their parameters. He has, in fact, done nothing but to recast a Sanskrit translation of an Islamic astronomical work into a form more congenial, and perhaps more acceptable, to an orthodox *jyotiḥśāstrin*.

Indeed, we have already seen that such a Sanskrit translation of a work dependent on Ulugh Beg's *Zīj* was available in the seventeenth century, in Benares as well as in Delhi. And a manuscript of a Sanskrit *Jica Ulughbegi* (*Zīj-i Ulugh Beg*) is preserved in the Mahārāja's Museum in Jayapur no. 45; it was acquired from Surata through Nandarāma Josī, who is probably the Nandarāma Misra who wrote voluminously on astronomy and astrology at Kāmyakavana in Rājasthān between 1763 and 1778.⁶⁸ We do not yet know whether this translation is identical with that used by Munisvara, Kamalākara, and Nityānanda. But that it was expected that translations of astronomical works would be made from Persian into Sanskrit (as they were under the Moghuls also from Sanskrit into Persian) is indicated by the existence of a special Persian-Sanskrit dictionary of astronomical terms intended to facilitate the process. This is the as yet unpublished *Parasiprakāśa* composed under the patronage of Shāh Jahān in 1643 by Mālajit,⁶⁹ a scholar from Srīsthals in Gujarat who was awarded the title of *Vedāngarāja* by the Emperor for his efforts.

One such translation that illustrates again the influence of the Samarqand school on Indian astronomers is the *Hayatagrantha*.⁷⁰ This was edited a decade ago on the basis of three manuscripts in Benares, of which the oldest was copied by Nāgesa in 1765. The editor believed that it was composed in Benares in the eighteenth century: for it refers to Kāshī several times,⁷¹

67. *Siddhāntarāja* 3, 19-85.

68. CESS A3, 128b-130b.

69. CESS A4.

70. Ed. V. Bhaṭṭācārya as *SBG* 96. Varāṇasi 1967.

71. *Hayatagrantha*, pp. 22, 95, 101-102, and 120-121.

In fact, Nityānanda further feels constrained to cast his expression of the mean motion parameters of the planetary theories of his Muslim source in the traditional Indian form, and to give instructions for deriving from mean longitudes computed according to the Romaka those computed according to the Saurapakṣa and the Brāhmapakṣa, presumably to demonstrate that differences already exist within the Indian tradition, and that therefore the unfamiliarity of the Islamic parameters is not to be regarded as in itself vitiating them. Thus the normal Indian divisions of the Kalpa and other units of time are described;⁵⁹ the mean motions of the planets, their nodes, and the zodiac (i.e., precession) are given as integer numbers of revolutions in a Kalpa;⁶⁰ and the computation of the *ahargana* follows the traditional pattern, though the epoch is noon at Lankā, which is (mean) sunrise at Romaka.⁶¹ The mean longitudes resulting from following these rules are then corrected by *bijas*, whose purpose seems to be to compensate for the inaccuracies involved in expressing the Islamic mean motions as integer rotations in a fixed time; Nityānanda states that they are necessary to bring the results into conformity with observations.⁶²

The dimensions of the Romaka's planetary models, however, are presented in Ptolemaic terms as eccentricities and radii of epicycles; and the circumferences of the *manda* and *tighra* epicycles of the Saura and Brāhma pakṣas are reduced by Nityānanda to the same terms.⁶³ The models themselves are thoroughly Islamic, with equants, protective spheres, and crank-mechanisms for the moon and Mercury.⁶⁴ The cosmology is almost equally Islamic;⁶⁵ the earth is surrounded by spheres of the Indian water, fire, wind, and space rather than the Aristotelian water, air, and fire, but beyond that come the seven planetary spheres in proper order. The eighth sphere, that of the zodiac, rotates at a precessional rate of 1° in 70 years; and the ninth sphere, crystalline and containing the constellations, rotates daily. Here there is no apology offered, nor indeed any justification of the presentation of these alien theories in Sanskrit.

Nityānanda's sine table, however, which gives the sine to five sexagesimal places for every degree from 1° to 90° with *R* equalling 60, is fully justified mathematically; for he gives complete rules for its computation, including Jāmshīd al-Kāshī's method (which was repeated by Qāḍī Zādah

59. *Siddhāntarāja* 2, 2-21.

60. *Siddhāntarāja* 2, 22-27.

61. *Siddhāntarāja* 2, 28-34.

62. *Siddhāntarāja* 2, 35-37.

63. *Siddhāntarāja* 3, 3-18.

64. *Siddhāntarāja* 3, 197 sqq.

65. *Siddhāntarāja* 3, 180-196.

66. WHMRL V 36 ff. 18v-19.

"Having examined the *Romakasiddhānta* [i.e. a *zij al-Rūmī*], the *Saura*, and that of Brahmagupta, and knowing the (longitudes of the) planets corrected separately (by each), I have composed an accurate *siddhānta*".

"It always attains in every way the equality between computation of the planets' (positions) and observation that comes from the *Romaka*. In this (science, however,) they know that the *Sauratantra* is like a Veda, and that even that composed by Brahmagupta possesses suitable methods".

"Then who was (this) *Romaka* who is numbered among the *munis*, the gods, and so on? I will tell you the answer to this (question); listen, as it was agreed to previously by Sūrya and Aruna":

"because of (their) fondness for history and stories. Even Bhāskara was known as *Romaka* because of a curse pronounced by Indra: Yavana lived in *Romaka's* city."

"When the curse was removed because of the favor of these two, the sun himself in ancient times composed the best treatise here, which has the form of tradition (*śruti*), though in the guise of being *Romaka's*".

Nityānanda has based this myth, as he himself indicates, on one in the *Jñānabhāskara* or *Sūryārūnasamvāda*⁵⁵ wherein Sūrya claims that he revealed the *Romaka(siddhānta)* to *Romaka* when he was born among the Yavanas because of a curse of Brahma, and that the *Romaka* was then revised by *Romaka* in *Romakanagara*. The author of the *Jñānabhāskara* was, I believe, thinking of the astrological *Romakasiddhānta* which claims to be part of a *Sṛiṣavāyanasamhitā*,⁵⁶ whereas Nityānanda refers to a work on Islamic astronomy. It is tempting, because of the name, to think of one of the works composed by Qāḍī Zāda al-Rūmī,⁵⁷ the teacher of and collaborator with Ulugh Beg perhaps his commentary on al-Jaghminī's *Mulakkkhaṣ fi al-hay'a*. Whatever the case may be, Nityānanda feels it necessary to justify Islamic astronomy to his audience not on the basis of a rational discussion of its methodology and an observational testing of its results (though he does state its superiority without adducing any evidence), but on the pretext of its being derived from the revelation of an Indian deity. Such a camouflage is certainly not new, as students of Abū Ma'shar's *Kitāb al-ulūf*, for instance, well know;⁵⁸ but it is significant that even the most enlightened Indian astronomer of the seventeenth century did not dare to base his claims on the evidence of the senses.

55. A. Weber, *Verzeichnis der Sanskrit-Handschriften* (Berlin, 1853), p. 287.

56. CESS A5.

57. Storey, p. 67.

58. D. Pingree, *The Thousand of Abū Ma'shar* (London, 1968).

Beg's *Zj*, for that *zj* seems not to describe the eccentric-epicyclic planetary models with the protective spheres (*pālī*) of Ibn al-Haytham and the later Islamic astronomers though Kamalākara does;⁴⁹ Kamalākara, however, does not mention the equant.

Moreover, Kamalākara speaks with approval of the computation of planetary distances by the Yavanas on the basis of the interesting of the solid (*mūrta*) spheres⁵⁰ – a computation that differs from the normal Indian procedure of making the distances of the planetary spheres inversely proportionate to the numbers of their rotations in a Kalpa.

It is not surprising, then, to find him quietly presenting as perfectly possible the Ptolemaic view of precession that Munisvara had so heatedly attacked.⁵¹ Nor is it uncharacteristic that his fifth *adhikāra* is a treatise on geometric optics, a subject never before, to my knowledge, discussed in such detail in Sanskrit. I presume that here also he has utilized an Islamic source, though I have not as yet been able to identify it.

Kamalākara, then, was quite willing to prefer a Muslim opinion even though it is contrary to that of the *ṛsis*. But he neither accepted the methodology of Islamic astronomy, nor abandoned the basic procedures, models, and parameters of Indian astronomy. Two decades before he wrote, however, another Indian astronomer had gone much further in accommodating Islamic science.

Nityānanda⁵² was a Gauda Brāhmana connected with the court of Shāh Jahān at Delhi. In 1628 he completed an enormous *Siddhāntasindhu*, which he dedicated to Shāh Jahān's minister Āsaf Khān; no manuscripts of this work are available to me. In 1639 he composed a smaller work, entitled *Siddhāntarāja*, in twelve chapters. Of this I have examined a fragment in the Wellcome Institute Library in London (V. 36). This manuscript of 39 folios (numbered 1-36 and 38-40) contains the first two and a large part of the third chapters of the work.

In the *Siddhāntarāja* Nityānanda boasts that he will present absolutely new (that is, Islamic) material, whereas his predecessors have merely repeated each other⁵³ – not an unjustified criticism of Indian astronomers. But he feels it necessary to disarm his critics in the following verses,⁵⁴ which I translate thus:

49. *Siddhāntatattvavivēka* 2, 255-284.

50. *Siddhāntatattvavivēka* 2, 497-500.

51. *Siddhāntatattvavivēka* 2, 470.

52. CEES A3, 173n-174n, and A4.

53. *Siddhāntarāja* 1, 9.

54. *Siddhāntarāja* 1, 14-16.

a particular fixed star. Thus he severely criticizes the Pārasīkas, their Yavana predecessors, and their Indian followers, for their arrogance in adhering to a doctrine dependent on their own deductions (*svamati*) even though they are contrary to the opinions of the *ṛsis*:⁴¹ at one point he even asserts that ridicule arises against anyone who has confidence in the words of the Yavanas on this matter through misunderstanding the true meaning of precession in Indian astronomy and trusting those observations that the Yavanas call *rasada* (Arabic *rasad*)⁴² Munīśvara's objections to precession were attacked by Kamalākara's brother, Ranganātha,⁴³ in his *Lohagolakhanda*, which in turn was assailed by Munīśvara's cousin, Gadādhara,⁴⁴ in a work entitled *Lohagolasamarthana*.

Thus Munīśvara's knowledge of the Sanskrit version of an Islamic astronomical work has not been allowed to influence his astronomical theories in any significant way. At best he refers with indifference to some aspect of Islamic science, but more commonly he feels at least obliged to deny validity to what he does find it necessary to mention. And his ultimate weapon against the observational basis of Ptolemaic astronomy is ridicule of what does not conform to the sayings of the ancient sages.

A more tolerant view of Islamic astronomy is manifested by Kamalākara in the *Siddhāntatattvavivēka* that he completed in 1658, as by his brother Ranganātha in his *Bhaṅgīvibhaṅgīkarana*.⁴⁵ Kamalākara agrees with the Yavana opinion that the inhabited parts of the earth rise above the sphere of water so as, however slightly, to alter the local horizon, though he hastens to add that this opinion does not contradict the gods and *ṛsis*.⁴⁶ Like Munīśvara he refers to Khēladatta, which he wrongly locates 22° West of Romaka; but he proceeds to give a set of the terrestrial coordinates – he calls longitude *tūla* (Arabic *tūl*) – of twenty cities.⁴⁷ The only cities on this list that are located outside of India are Kabul and Samarqand; and in the seven cases where cities are included in Ulugh Beg's geographical lists, the coordinates, with the exception of a few misreadings of *abjad* numbers, are identical.

Kamalākara confirms his acquaintance with Ulugh Beg by referring to the computation of a table of sines by "Mirjolukabega".⁴⁸ This knowledge probably reached him, however, through a more elaborate treatise than Ulugh

41. *Siddhāntatattvavivēka* 1, 36-39 l. 123.2, 253-254 and 2, 274-275.

42. *Siddhāntatattvavivēka* 2, 279.

43. CESS A5

44. CESS A2, 115a

45. *Bhaṅgīvibhaṅgīkarana*, pp. 31-32

46. *Siddhāntatattvavivēka* 1, 120-126.

47. *Siddhāntatattvavivēka* a. 17° 174; Essay Table VIII 27

48. *Siddhāntatattvavivēka* 2, 89.

section of the *Siddhāntasīromani*.³⁴ In this he criticizes the theory of the Yavanas (i.e., the Muslims) that there is an unmoved crystalline (*kāca*) sphere supporting the sphere of the constellations (*mūrtimā*) and enabling it to rotate daily from East to West. for, he says, the crystal could not bear such a weight, especially since the sphere of the constellations in its turn bears the weight of the sphere of the zodiac. What else he might have derived from a Muslim source I do not know, as I have not had an opportunity to examine manuscripts of his other works.

The same is also true of most of the *Siddhāntasārabhaṣma*, which was completed by Munīśvara³⁵ on 7 September 1646; of its twelve adhyāyas, on which Munīśvara wrote his own *likā*, only the first two and part of the third have been published with their commentary. In these chapters are found such relatively trivial matters as the recording of the definition of a sidereal month according to the Pārasīkas³⁶ (Munīśvara claims that the concept is useful for astral omens, but not in astronomy): it is stated that the origin of longitudes in the geographical tables of the Pārasīkas is a city called Khāladāta near Romaka³⁷ (in fact, of course, this place is the Eternal Islands - *al-jazā'ir al-khālidat* - of Arabic geographers); it is claimed that, even though the methods of the Pārasīkas for correcting the mean longitudes of the planets beginning with the moon are described in the language of the gods (that is, in Sanskrit), yet they must be rejected by the wise because they are without proof;³⁸ and it is mentioned that, whereas for the orthodox the blue sky is a sphere of metal (a *lohaśloka*), the Pārasīkas claim that the heavenly spheres are crystalline.³⁹ All of these matters, even the last, seem to trouble Munīśvara very little; the reader is warned against some, but never in a very emphatic manner. He was much more incensed by the theory of precession when understood to imply a tropical rather than a sidereal reference system. For the Indians, though they have various theories of precession and trepidation,⁴⁰ traditionally used them only for the correction of the sun's declination; the juncture of the sun's declination circle with the equator may be permitted to move with respect to the fixed stars, but the traditional Indian method of describing mean motions as integer numbers of sidereal rotations within a *Kalpa* or a *Mahayuga* necessitated, in Munīśvara's opinion, the unswerving connection of the origin of the zodiac with

34. *Māricī* 1, 2, 1-6.

35. CESS A4.

36. *Siddhāntasārabhaṣma* 1, 17.

37. *Siddhāntasārabhaṣma* 1, 136.

38. *Siddhāntasārabhaṣma* 2, 222.

39. *Siddhāntasārabhaṣma* 2, 228.

40. D. Pingree, "Precession and Trepidation in Indian Astronomy before A. D. 1200", *Journal for the History of Astronomy*, 3 (1972), 27-35.

are repeated often in Islamic zijes. These Goal-year periods, with the exception that Venus' eight-year period was altered to a 227-year period, were soon used as the basis of an enormous set of planetary tables, the *Jagadbhūṣana*, compiled by Haridatta²⁷ in Mewar in Rājasthān in 1638; Haridatta, however, apparently used an Indian rather than a Persian set of astronomical tables in carrying out the computations of his own tables; the same is true of Trivikrama,²⁸ who composed a similar set of planetary tables based on the Goal-year periods at Nalinapura in 1704. Their knowledge of the Goal-year periods, then, simply provided a convenient framework for a form of perpetual tables, as it had in the West for al-Zarqālī and his source and successors.

In Benares in the eighteenth century the most important astronomers belonged to two Mahārāṣṭrian Brāhmaṇa families which had migrated to the city in the sixteenth century. The descendants of Cintāmani, a member of the Devarātragotra residing at Dadhigrāma on the Payoṣṇī, include Munīśvara Viśvarūpa,²⁹ who was born in 1603, the year in which his father, Ranganātha,³⁰ completed his famous *likā* on the *Sūryasiddhānta*, the *Gūḍhārī-aprakāśikā*. Munīśvara's great rival was Kamalākara,³¹ who was descended through Divākara, a pupil of Ganeta, from Rāma of the Bhāradvājagotra, a resident of Golagrāma on the Godāvarī, not more than a few days' journey from Dadhigrāma. These two men and their numerous siblings, cousins, and nephews were all engaged in astronomical activities, but always within the context of the traditional Indian siddhāntas, particularly those of the Saura and Brāhma pakṣas. From time to time, however, they display an awareness of Islamic astronomy, which seems to have been available to them in the form of a Sanskrit translation of the *Zij* completed by Ulugh Beg³² at Samarqand in about 1437/1438 or some derivative of that *zij*. The precise source of their knowledge remains obscure, however, we will return to the question of the Sanskrit versions of Ulugh Beg's astronomy later in this paper.

The earliest of these Benares astronomers to demonstrate a knowledge of Islamic astronomy is Kamalākara's father, Nṛsimha,³³ who wrote a commentary on the *Sūryasiddhānta* in 1611 and one on the *Siddhāntasiromaṇi* of Bhāskara in 1621. Unfortunately, of these two gigantic works all that has been published is his commentary on the first adhikāra of the *grahaganita*

27. CESS A6.

28. CESS A3, 92b-93b, and A4.

29. CESS A4.

30. CESS A5.

31. CESS A2, 21a-23a, A3, 18a, and A1.

32. CESS A4. Storey, pp. 67-72.

33. CESS A3. 204a-206a.

of the astrolabe stars – Mahendra is quite willing to substitute Islamic procedures and values for the Indian, without any apparent effort to determine in what sense they might be superior; it was easier to take them over than to recast them in an Indian mold. In the other elements of astronomy he gives no indication that it is at all advisable to abandon or modify existing Indian theories.

The next major infusion of Islamic astronomy into science in Sanskrit seems to have occurred under the Moghuls, who, like Firūz Shāh, promoted intellectual exchanges between their Muslim and Hindu subjects. I employ the word “major” because there is one minor case of transmission that cannot be ignored. The Kerala astronomer, Acyuta Piṣāraṭi,¹⁹ in his *Sphuṭanirṇaya* and *Rāṭigolaspṭhānī* written in the 1590’s, proposed a formula for reducing the mean longitude of the moon in its orbit to an ecliptic longitude. Such a reduction had first been suggested, by Yahyā ibn Abi Maṣṣūr in the *Zīj al-mumtaḥan*, composed under al-Ma’mūn in the 820’s. Acyuta probably bears witness to some transmission of at least a part of Islamic lunar theory that took place on the Malabar Coast in the fifteenth or sixteenth century.

A survey of Sanskrit astronomical texts composed in Western and Northern India in the sixteenth century, however, has yielded no reflexions of Islamic astronomy. I have examined, among others, the works, published and unpublished, composed by Jñānarāja²⁰ at Pārthapura on the Godāvari in 1503; by Gaṇeśa²¹ at Nandigrāma in Gujarat between 1520 and 1552; by Dinakara²² at Bārejya in Gujarat between 1578 and 1583; by Gaṇeśa’s nephew and pupil, Nṛsiṃha,²³ at Nandigrāma between 1588 and 1603; and by Rāmacandra²⁴ at Benāres between 1590 and 1600. Members of the families of several of these sixteenth century astronomers, however, were the leading advocates and critics of Islamic astronomy in Benares in the seventeenth century.

But the first author to whom we must refer is Viśrāma from Jambūsara in Gujarat, who wrote a description of various astronomical instruments, the *Yantraśiromani*,²⁵ in 1615. What is of immediate interest to us in his work is the inclusion of the Babylonian Goal-year periods of the planets,²⁶ which, of course, figure prominently in Book IX of Ptolemy’s *Almagest*, and

19. CESS A1, 36b-38b, and A4. *Rāṭigolaspṭhānī* 47; *Essay IX* 2

20. CESS A3, 75a-76b.

21. CESS A2, 94a-106b.A3, 27b-28a, and A4.

22. CESS A3, 102b-104b, and A4.

23. CESS A3, 202b-204a.

24. CESS A5.

25. CESS A5.

26. *Yantraśiromani* 92-94.

is probable that he derived this second component also from an Islamic source. It was also known to his contemporary, Bhojarāja,¹³ who wrote the *Rājasmṛāṅka*, with epoch of 21 February 1042, at Dhārā in Mālava.

It is highly unlikely, however, that this source should have been the translations of Euclid's *Elements* and of Ptolemy's *Almagest* that al-Bīrūnī claimed, in about 1030, to be engaged in.¹⁴ This claim must be regarded as sheer bravado, since the knowledge of astronomers' Sanskrit displayed by al-Bīrūnī and his paṇḍitas was totally inadequate to the task. Another channel of scholarly exchange must be imagined, and of a more limited character; the only elements of Islamic astronomy that appear in Sanskrit texts at this early date relate to the sun and the moon.

The next phase in the transmission of Islamic astronomy to India, if we regard Bhāskara's¹⁵ innovations in trigonometry as entirely his own, was the introduction of the astrolabe into Western India under the Tughluqs. Mahendra Sūri¹⁶ composed the first description of this instrument in Sanskrit, the *Yantrarāja*, at Bhṛgupura - that is, modern Broach in Gujarat - in about 1370; according to his pupil, Malayendu,¹⁷ who wrote a commentary on the *Yantrarāja* in about 1382, Mahendra undertook to write his treatise at the request of the astronomers of Firūz Shāh (1351-1388), during whose reign Sanskrit works were also translated into Persian. The astrolabe itself, of course, was developed in the Roman empire, though our earliest extant examples are Arabic. Mahendra and Malayendu not only introduced the construction and use of the instrument to Indian astronomers, but also an Islamic sine table in which R equals 3600 or 1, 0, 0; a table of declinations with the Islamic value, $23;35^\circ$, for the obliquity of the ecliptic; a list of the latitudes of 77 cities, most of which are in India though many are located elsewhere in the Middle East (the Ptolemaic system of representing terrestrial coordinates had not previously been used in Sanskrit texts); a catalogue of 32 astrolabe stars whose coordinates are derived from the *Almagest*, with the Ptolemaic longitudes corrected for precession (at the rate of 1° in 66 $2/3$ years) for 1370; and the cotangent tables normal on the backs of Eastern Islamic astrolabes.¹⁸ Thus, in those elements necessary for the use of the astrolabe - trigonometry, terrestrial latitudes, and the coordinates

13. CESS A4. *Rājasmṛāṅka* 1, 25; Essay V 124.

14. D. Pingree. "Al-Bīrūnī's Knowledge of Sanskrit Astronomical Texts", in *The Scholar and the Saint* (New York, 1975), pp. 67-81.

15. CESS A4. *Siddhāntasūtra* 1, 2, 23; Essay Table V 43, and jyotipatti 16 and 21. Essay V 127-128.

16. CESS A4.

17. CESS A4.

18. *Yantrarājajīkā* 1, 5-6, *Yantrarāja* 1, 22-40, and 1 70. Essay Tables XI 1 - XI 3.

between the sun and the moon. The result of Ptolemy's model, with its specified dimensions, is that the maximum equation at syzygies is $5;1^{\circ}$, at quadratures $7;40^{\circ}$. In the tenth century a model producing an identical effect first appears in India. The epoch of Muḥjāla's' lost *Bṛahmaṇasa* is 9 March 932 at noon (noon-epoch in itself is characteristic of Ptolemaic and Islamic astronomy, but alien to India); his extant *Laghumānasa* was commented on by Prasastadhara⁸ in Kāsmīra in 958; and both of these treatises were encountered by al-Bīrūnī in the Pañjāb in the 1020's. It is likely, therefore, that, although Muḥjāla's *Laghumānasa* is now found only in South India, he originally composed it in the West or Northwest, and had contact there directly or indirectly, with Muslim astronomers.

Muḥjāla, however, following the Indian tradition, did not regard planetary models as cinematic or as in any way representing physical reality, but as calculating devices. Thus he felt free to replace Ptolemy's crank mechanism with an elegant formulation of the evection.⁹

$$0 = (\bar{v}_m - 11^{\circ}) \cdot \cos(\lambda_s - \lambda_a) \cdot \sin(\lambda_m - \lambda_s),$$

where λ denotes celestial longitude, and the subscripts m , s , and a denote moon, sun, and apogee respectively. Because of his choice to express his parameters as integer parts of a radius of 488, his simple lunar model generates a maximum equation of $5;2^{\circ}$; while his formula for evection, since he employs the integer 11 $^{\circ}$ in the first factor, results in a maximum of about $2;29^{\circ}$, so that Muḥjāla's maximum lunar equation at quadratures is $7;31^{\circ}$ instead of Ptolemy's $7;40^{\circ}$.

A result closer to Ptolemy's was provided by Śrīpati,¹¹ who wrote various works between 1039 and 1056, at Roṇīkhanda, about 150 miles south of Ujjayīnī. Śrīpati accepts the Brāhmapakṣa's simple lunar model with an epicycle that pulsates in a complex fashion as the body approaches the horizon, but which at its mean, in the meridian, produces a maximum equation of $5;2.7^{\circ}$. For the evection Śrīpati¹² accepts Muḥjāla's formulation, but modifies the first term so that the maximum correction is $2;40^{\circ}$ —just 1 minute more than Ptolemy's—and the maximum equation at quadratures, when the center of the moon's epicycle is on the meridian, is $7;42.7^{\circ}$.

Śrīpati also gives a complete formulation of the equation of time including both that part which is due to the sun's velocity, which had already been known to Brahmagupta,¹³ and that dependent on the sun's longitude. It

7. CESS A4.

8. CESS A4.

9. *Laghumānasa* 18-19, Essay IX 1.

10. CESS A6.

11. *Siddhāntasākhya* 11, 2-4; Essay v 123.

12. CESS A4. *Brāhmapakṣasiddhānta* 2, 29. Essay V 66.

of planetary motion to scientists of the early 'Abbasid period,' emphasized perhaps over-emphasized the role of observation in refining planetary theories, and because of this emphasis developed both the necessary instruments and theories of optics and of the behavior of light. The most noteworthy Indian reaction to these aspects of Islamic astronomy, though characteristically having no discernible practical effect, was the program for the reform of Indian astronomy instituted by Jayasīma, the Mahārāja of Amber from 1700 till 1743.² Under his patronage were built the massive observatories at Vārāṇasī, Ujjayīni, Mathura, Dillī, and his own Jayapura, while under his patronage the industrious Jagannātha³ translated Euclid's *Elements* and Ptolemy's *Almagest* into Sanskrit, and the less well-known Nayanasukhopādhyāya,⁴ at the dictation in Persian of Muḥammad Ābida (who acted as an intermediary in the way that Spanish-speaking Jews had for some of the Latin translators of Spain in the twelfth and thirteenth centuries) translated Theodosius' *Spherics* and Naṣīr al-Dīn's *Tadhkira* with al-Barjandī's *Sharḥ* thereon. But these achievements, impressive though they might appear, were at the end rather than the beginning of the Islamic influence on Indian astronomy. Let us turn now to the predecessors of that beginning.

Non-Ptolemaic forms of Greek astronomy, sharing many characteristics with what we can reasonably reconstruct of the theories of Hipparchus, were transmitted to India in the third or fourth century A.D., including several alternative planetary models and mathematical descriptions of other celestial phenomena;⁵ these were given their characteristic Indian expressions in the fifth, sixth, and seventh centuries, from which developed four of the five schools of astronomy or pakṣas - in chronological order the Brāhma, the Ārya, the Ārdharātrika, and the Saura. These astronomical schools were generally conservative, but did permit the development of new computational techniques; and it is in the mathematics ancillary to astronomy - trigonometry and indeterminate equations - rather than in astronomy itself that the Indians excelled. There was no tradition of systematic observation in early Indian astronomy.

The Hellenistic lunar model that was transmitted to India allowed for only one inequality in its motion, which was accounted for by an epicycle; Ptolemy's model had a more complex structure, with the center of the moon's deferent traveling on a concentric at double the rate of the mean elongation

2. D. Pingree, "The Greek Influence on Early Islamic Mathematical Astronomy", *Journal of the American Oriental Society*, 93 (1973), 32-43.

3. CESS A3, 63a-64b, and A4.

4. CESS A3, 56a-58a, and A4.

5. CESS A3, 132a, and A4.

6. D. Pingree, "The Recovery of Early Greek Astronomy from India", *Journal for the History of Astronomy*, 7 (1976), 109-123.

Islamic Astronomy in Sanskrit

DAVID PINGREE*

The problem that I wish to examine in this paper involves in particular the awareness of and reaction to Islamic astronomy on the part of the traditional Indian astronomers practicing their science in northern India under the Moghuls. But in more general terms I believe that it illustrates the characteristic methods by which Indians throughout their history, until the nineteenth century, have responded to a superior foreign science (the judgment of superiority is here based on experience rather than on theory), though in the last phases of Moghul astronomy in Sanskrit one can perceive the beginnings of a new attitude foreshadowing that which has become the prevalent one among contemporary Indian scientists. Briefly, the shift in attitudes to which I allude is from the classical position that alien scientific systems may be adopted to Indian use, but that they must somehow be made to conform to the older Sanskritic tradition, and the resulting mutation ought to be presented as the revelation of a divinity or of an *ṛṣi*; the attitude of the contemporary Indian scientist is, normally, that there is one scientific method, internationally approved of and validated by experience and by its pragmatic success, and that the views expressed by gods and seers in the past are not guides to scientific truth, though some weaker souls may wish to vindicate them by reinterpreting them to conform to, and thus to anticipate, contemporary scientific hypotheses.

In the seventeenth and eighteenth centuries Indian intellectuals were forced to respond to a forerunner of modern science in the form of Ptolemaic astronomy as practiced by Muslims.¹ Though accepting Aristotelian physics, Muslim astronomers for a variety of reasons, not the least of which was the availability of the conflicting Ptolemaic and Indian models and parameters

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1. For biographical and bibliographical information on the authors discussed in these pages I refer the reader to D. Pingree, *Census of the Exact Sciences in Sanskrit* (henceforth CESS), of which Series A, vols. 1-3 have appeared as *Memoirs of the American Philosophical Society*, vols. 21, 26, and 111 (vol. 4 is in press), and to C. A. Storey, *Persian Literature*, vol. 2, part 1 (henceforth Storey), (London, 1958). See also D. Pingree, "Essay on the History of Indian Astronomy" (henceforth *Essay*, cited according to formulas and tables) in *Dictionary of Scientific Biography*, vol. 15, (New York, 1978), where the few technical matters touched on in this paper are discussed, and B. Datta, "Introduction of Arabic and Persian Mathematics into Sanskrit Literature", *PBMS* 14 (1932), 7-21.

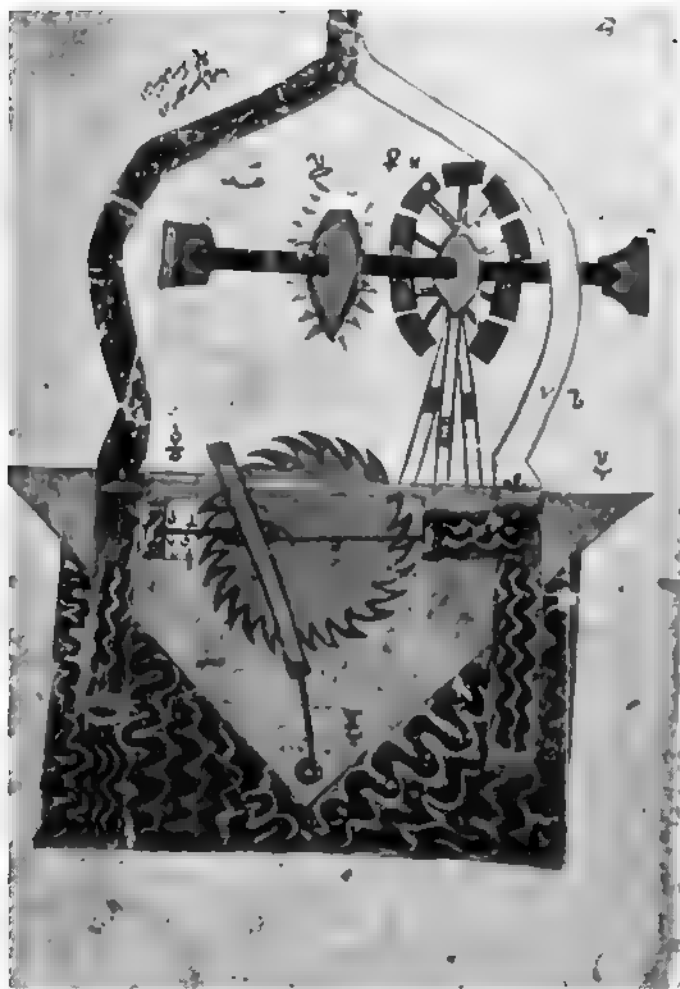


Fig. 7.

The main illustration of the complete machine: it is probable that this is a plan view, rather than an elevation (see Hansen *op. cit.* 56-59).

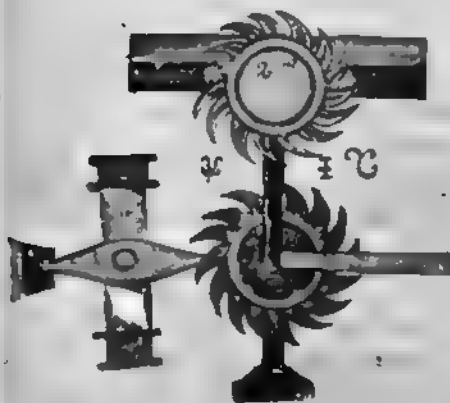
المشرق البرق فاق رداة ويرفع وينطق رداة كالمواجد بالآهين
 انبوب فممثل ريح اما رديف مع قضيب انطقت رداة
 وانفت النار وروح رداة كوصد الماء في انبوب ك
 الدقيق بالافق نحو عشرين ذراعا وهو سافه طول الانبوب لم
 تغد ريح آخر هذه النصفه المنقوشة وما ينطق به وتعمل البرق

هذا وانبوب عليه لا وفيه رداة عليها كالمواجد من في
 انبوب عليه فوديق وفيه رداة عليها كالمواجد من في
 خلفه وعلى الطرف الاخر رداة فيها ثوب عليه كالمواجد
 غير ذلك يخرج في ارض الضيق وفي من جهة اخرى
 ويترك فيه انبوب سمن ريح الى حد صفه ويرتفع اليه
 ويحل ريح على جالات ثابته ويرتفع ويخرج انبوب من اعلى
 الصندوق معكبا الوجه وسطه وقد حل وسط جانبيه في سمن
 في عند نقطه ردة قد اجبرت في حلقه طرف قضيب وكذلك
 يوصف البرق الاخر في زاوية من الصندوق وقد حل وسط
 جانب اخرى السهم ردة قد اجبرت في حلقه طرف قضيب ليرتفع
 بين السهمين نحو سمن قسار القديع الذي من ريح على انبوب
 وارفع من انبوب سمن الى ريح او فوقها السهم من القديع الذي
 من ريح اسف انبوب وارفع في انبوب لا مالى ريح سمن

Fig. 6.

A drawing of one of the two cylinders — the ring at the end of the connecting rod is attached to the side of the slot-rod.

من المجرى الى ارض الصدوق يدور على سطحه وتجب القوس
 قطعه يدور بها المجرى وعلى دايه القوس ديدانجات باوزان
 عن الصدوق وعلى القوس في داخل الصدوق وعلى
 الدندجات وهي حارجه عن جانب الصدوق وعلى
 القوس وتندخل في منجرجه ثم تحت سهم واحد في احد طرفيه
 ثقب فيه سائر ثقات عند زاوية عن من الصدوق والطرف الاخر



مخروفي طولاً من طرفه
 قطر دايه يوزن ما راس
 وتجا القوس وهو في
 الخرق يصير الوند في
 عابه يدور على زاوية
 من الصدوق في طرفه
 الخرق وعلى سطح الخرق
 لها لآل وعلى وسط
 الخرق مينا ما تسمى
 ولا لآل له الخرق
 كما ان جهه من وهو
 بالمدينة من طينها

ومنى ما درمى ومن جهه الخرق يدور على دورته فان وند
 القوس الى ناحية من ويكمل معه سهمه وهو عايشه مائة
 ويحسب قوس واما حتى يدور ويح دورته ويسمى الوند الخرق

Figs. 5, 6, and 7
(V.5, Figs. 139, 140, 141)

These illustrations are of the second of the alternative designs of the well-known slot-rod pump.

Fig. 5.

The two meshing cogwheels, the upper one driven from a paddle-wheel, the lower one having the slot-rod on its face. The orientation of this sketch is the same as in Topkapı 3472, whereas in Oxford Graves 27 it is turned through 90 degrees. The orientation shown here is almost certainly correct. The cogwheels are shown disengaged, otherwise the illustration is good.

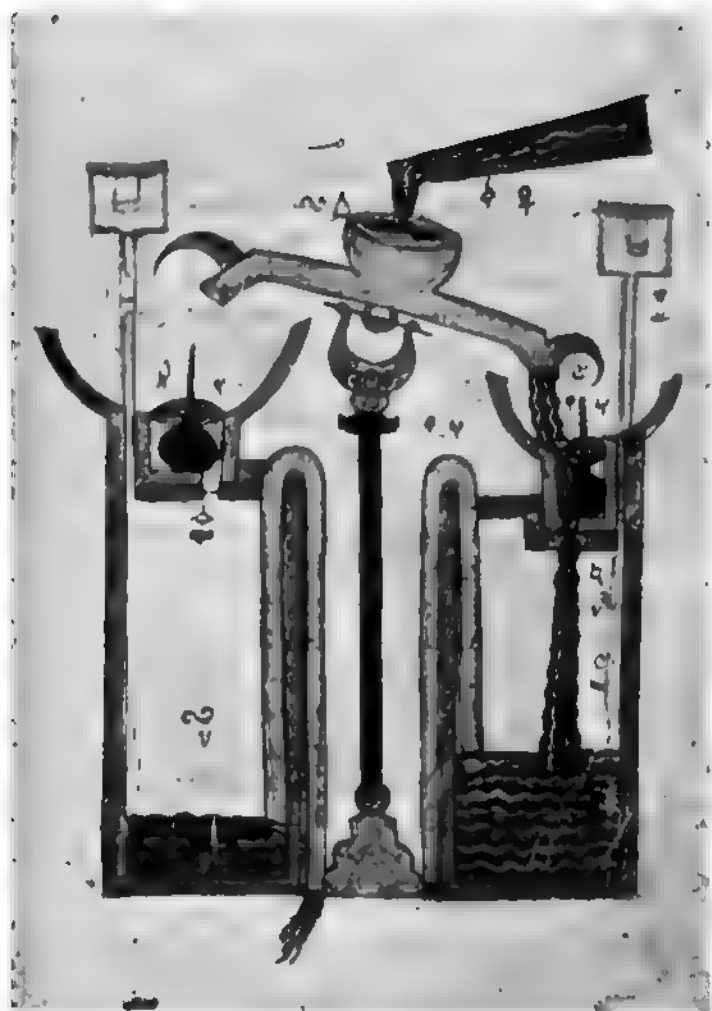


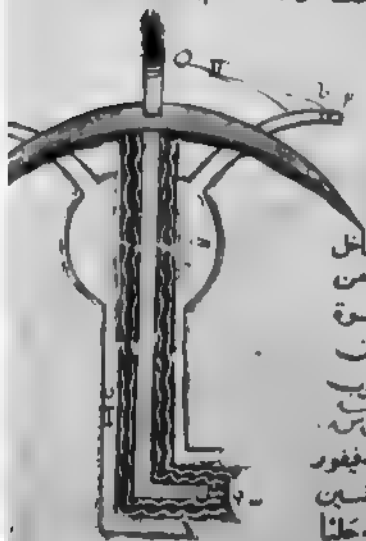
Fig. 4.
(IV. 10, Main illustration, Fig. 133).

Musical automaton. The whistles are at either side, at the top. air-pipes lead into them from the two tanks. The water runs into one side from the balanced supply pipe, causing the whistle to sound, until the float in the chamber at the top of the tank rises. The vertical rod on top of the float causes the supply pipe to tilt and discharge into the other tank. A siphon evacuates the first tank. The cycle repeats itself as long as water flows into the system.

الى فؤارة ح فيفور منها صولجانا وكذلك ما دام الماء يجري من
 انبوب ك وذلك ما اردت ايضا ح طيا واقول ان لهذا
 الشكل وجه ثاني وممكن به ان يجر احد الفوارين جميعه
 ونفسيا واحدا ويجور الفؤارة الاخرى صولجانة ستة ثم يبدلان

ما يما وامثل ذلك صورة
 واسم يقوم مقام الاخرى
 وذلك ان انبوب ه يجري
 فيه الماء من حوض ص
 الصخرة م ويجور منها في
 انبوب ستة كقطع قسي

ينفذ في الدرقين ك وفي داخل
 انبوب الصخرة انبوب ه فيه الماء من
 حوض س ويجور من راسه بقوة
 ويتلقاه مقعدا الدرق فيعمل من
 ماير فاجية وفي وسط هذا الانبوب
 انبوب آ يجري فيه الماء من حوض س
 ويرتفع حتى ينفذ في مركز الدرق فيفور
 فنيا وهذا الشكل خارج عن الحسين
 فعلا وذلك ما اردت ايضا ح جلبنا



والصنف تاسعته وهو فؤارة قنديل الشكل نصف دائرة مستوية
 الشكل الخامس من النوع الرابع

Fig. 3.

(Addendum to IV.4, Fig. 125)

A fountainhead having three possible shapes. It is supplied from two tanks, with a switching system similar to that described for Fig.4 below. Three concentric pipes enter the fountainhead, the two inner ones from one tank, the outer one from the other. Water from the innermost pipe emerges as a straight jet; it emerges from the second pipe as a 'tent' - the water impinges on a convex plate and descends as a curved sheet. After change-over it emerges from the outermost pipe as a number of curved jets.

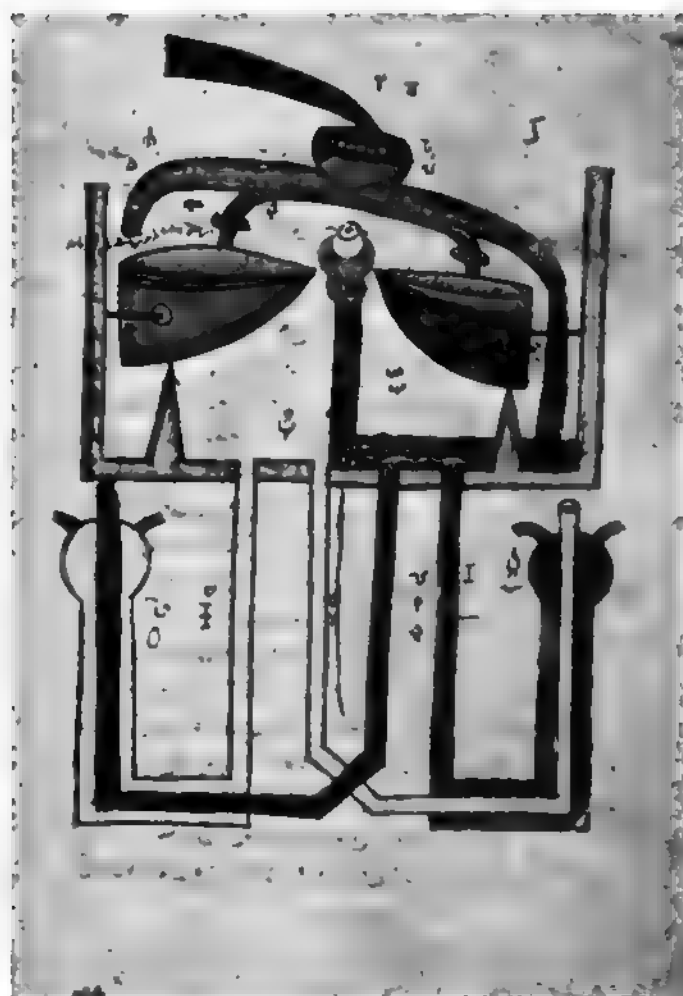
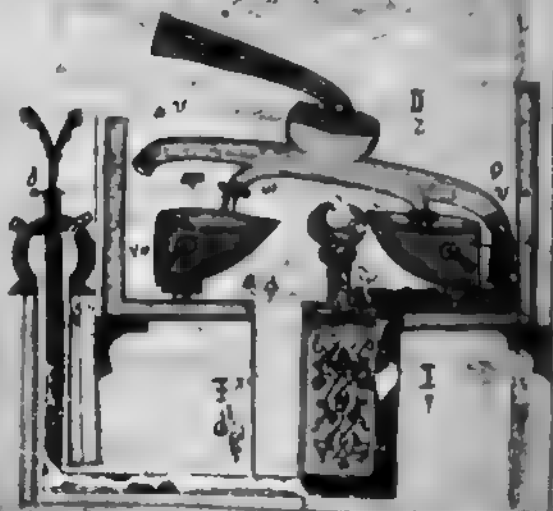


Fig. 2.
(IV.2, Main illustration, Fig. 122)

This is a doubled version of IV.1. One fountain-head emits a single jet when the other is discharging several. When they change over, the situation is reversed. Again, the rods attached to the tipping-buckets are omitted.

ففوقه مناسخ ولكن على كفة مناسخ من المناشفة ارطال بالبندي
 وخرج كوكبة تحت انبوب من الارض من الصخرين الذين عليها
 قرون وضاعتها وكذا عليها منسوب اليها انبوب وحق تحتها مياه
 ملوكة خرج من حجرة في طرف انبوب في ساق مستوية ما عاين
 وتخرج ما فيها من الماء الى حوض وخرج من حوضها شطبة متصلة بالانبوب
 فيل انبوب الكبر وجب الى حوض والى كفة تحت انبوب وعلى
 حوضها انبوب على سلم يخرج من حجرة في انبوب ثم يفتح ما فيها من الماء
 حوض وخرج من حوضها شطبة متصلة بالانبوب فيعود الى حوضها
 حوض والى كفة من حوضها مياه ام لا يخرج في ساقية الى حوضها



Illustrations

(The numbers in parentheses give the Category, Chapter, and Figure Nos. from Bill)

Fig. 1

(IV. 1, Main illustration, Fig. 121)

A fountain made to alternate by bleeding water from the main supply pipe, which is free to oscillate about an axle, into one or other of the tipping-buckets. As shown here, the discharge is into the right-hand side. When the tipping-bucket fills, it tilts and a vertical rod soldered to its rear face pushes the supply pipe, causing it to tip towards the left. The vertical rods are not shown in this illustration but appear in the parallel illustration in Topkapı 3472

The fountainhead emits a straight jet when supplied from the left-hand tank, and several curved jets when supplied from the right.

the end of Chapter 10 of Category IV. The first part describes a woodwind instrument having 'fingers' that are raised and lowered in succession over its holes by cams fixed to the axle of a water-wheel. There is no illustration for this instrument. The second part of the addendum describes the device shown in the illustration mentioned above. This is a rocker-arm consisting of two flume-beam swapes joined at right angles, and oscillating about an axle located at the joint. The oscillation is produced by the 'bleeding' of water through a narrow pipe from the main supply channel into whichever of the flumes is temporarily horizontal; when the scoop at the end of the flume fills, this side tilts and the other flume comes to the horizontal and its scoop begins to fill, and so on. Al-Jazari says that this device was not only used for fountains and musical automata, but that it was incorporated in many different machines.

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1. A. K. Coomaraswamy, *The Treatise of al-Jazari on Automata*, Museum of Fine Arts, Boston, 1924.
2. A. Y., Hassan, *A Compendium of the Theory and Practice of the Mechanical Arts*, Arabic text of al-Jazari's work, collated from three of the best manuscripts. (Aleppo, Institute for the History of Arabic Science, 1978).
3. *Idem*, 'The Arabic Text of al Jazari's "A Compendium of the Theory and Practice of the Mechanical Arts"', *Journal for the History of Arabic Science*, Aleppo, Vol. 1, No. 1, 1977 47-64 in English, 129-165 in Arabic.
4. Donald R. Hill, *The Book of Knowledge of Ingenious Mechanical Devices*. An annotated translation of al-Jazari's work. (Dordrecht, Reidel, 1974).
5. Sotheby, *Spring Islamic Sales*, catalogue for sale on 3rd April, 1978, 122-127.
6. E. Wiedemann, and F. Hauser, 'Über die Uhren im Bereich der Islamischen Kultur', *Novi Acta Abh. der Kaiserl. Leop. Deutschen Akademie der Naturforscher* 100, Halle 1915, 1-168.

The colophon is on page 293, after the end of VI. 5. On page 294 the letters of the 'secret' alphabet are given with their equivalents from the normal Arabic alphabet; the few lines of explanatory text are in a different handwriting from the rest of the manuscript - it is a badly written *naskhi*. There are three illustrations on page 295. The largest of these is in the centre of the page and is the main illustration of II.1, i.e. Fig. 80. It is clearly by a different draughtsman than the one who drew the illustrations for the main part of the manuscript; it is badly drawn and would be almost useless for explanatory purposes. Lower down, to the right and left of the page are two small, crude sketches of devices similar to those described by the Banū Mūsā, indeed the one on the right can be identified as their Model 79. Above either sketch there are passages describing these two devices (there is no text relating to the al-Jazari device). These descriptions are not in the words of the Banū Mūsā. The handwriting is different again, a somewhat better *naskhi* from that on page 294, but not as good as that of the main manuscript. At the bottom of the page there is the start of a passage in Fārsi, which continues on page 296. This passage, in yet another *naskhi* hand, is part of a treatise on weighing; at the bottom of the page there is a drawing of a balance with five pans. The contents of page 294 appear in most of the al-Jazari manuscripts, and this page was probably added to supply an obvious omission. Pages 295 and 296, however, are quite extraneous.

Summarising from the foregoing tabulation, the only absolutely complete chapters are: III,1. - pitcher for dispensing hot and cold water; III,2. - pitcher for dispensing water; III,4. - peacock for dispensing water; IV, 1 to 6. - fountains; IV, 9 and 10. - musical automata; V,1. - pump; VI,2. - protractor; VI,3. - combination locks. All the illustrations are included in these fourteen chapters with, of course, all the main illustrations. There are also another five main illustrations which appear in incomplete chapters, namely: I,9., Fig. 76 - monkey candle-clock; I, 10., Fig. 78 - candle-clock of the doors; IV, 7 and 8., Figs. 130 and 131 - musical automata; VI,5. Fig.173 - water-clock of the sailor. Half of the illustration of the door, VI, 1., Fig. 141, remains. This fine miniature was originally on one full folio, and it seems likely that the other demifolio is lost for good. Fourteen of the dispersed main illustrations were published as plates in Hill, *op. cit.*, so we now have a record in two documents of 33½ of the original 50 main illustrations.

There are three chapters on water-raising machines, namely V, 1, 2 and 4, for which the text is complete although there are no illustrations.

In Hill, p. 238, Plate XXXII shows a device for which there was no description in the manuscripts that were available to me when I made the translation. There is, however, an addendum, to the text in the manuscript under review and in Topkapi 3472; in both cases this addendum occurs at

Category	Chapter	Pages in new numbering	Original contents	Omissions	
				Illustrations	Text
IV	Intro- duction	212	Text only	None	All except last two lines
	1 to 10	212 to 245	10 Chapters Figs. 120 to 133, Pl. 32	This Category is complete, with all the illustrations, except for the following part of the text: end of chapter 7, start of chapter 8	
V	1	245 to 248	1 Section Fig. 134	134*	None
	2	248 to 250	1 Section Fig. 135	135*	None
	3	250, 251	2 Sections Fig. 136	136*	End of S.1, start of S.2
	4	251 to 253	1 Section Fig. 137	137*	None
	5	253 to 260	3 Sections Figs. 138 to 141*	None (This chapter	None) is complete)
VI	1	261 to 264, 269 to 273	3 Sections Figs. 142 to 148	Half of 142*	Introduction, start of S.1 (section 2 is complete but is misnumbered as section 1)
	2	273 to 277	3 Sections Figs. 149 to 152	None (This chapter	None) is complete)
	3	277 to 286	2 Sections Figs. 153 to 166	None (This chapter	None) is complete)
	4	287 to 290	2 Sections Figs. 167 to 172	172*	End of S.2
	5	291 to 293	1 Section Fig. 173	None	Last paragraph

Category	Chapter	Pages in new numbering	Original contents	Illustrations	Omissions
					Text
III	1	170 to 175	2 Sections Figs. 103, 104*	None (Chapter is complete)	None
	2	175 to 183	2 Sections Figs. 105 to 108	None (Chapter is complete)	None
	3	183 to 188	2 Sections Figs. 109 to 111	111*	Middle of S.2
	4	188, 189, 265, 266	1 Section Fig. 112*	None (Chapter is complete)	None
	5	266, 267	2 Sections Fig. 113	113*	Most of the chapter
	6	267, 268, 190 to 193	2 Sections Figs. 114, 115	114, 115*	Last few lines of S.2
	7	194 to 196	2 Sections Fig. 116	116*	Start of S.1, middle of S.2
	8	196 to 201	2 Sections Fig. 117	117*	End of S.2
	9	202 to 207	4 Sections Fig. 118	118*	Start of S.1, end of S.4
	10	208 to 211	2 Sections Fig. 119	119*	Start of S.1, end of S.2

Category	Chapter	Pages in new numbering	Original contents	Omissions	
				Illustrations	Text
I	9	108 to 110	2 Section Fig. 76*	None	All S.1 except last two lines
	10	110 to 113, 130, 131	2 Sections Figs. 77, 78*	None	End of S.2
II	1	114 to 117	2 Sections Figs. 79, 80	80*	All S.1 except last three lines
	2	117, 118	1 Section Fig. 81	81*	Middle of Section
	3	119 to 129, 132 to 139	5 Sections Figs. 82 to 86	82*	End of S.1
	4	139 to 145	3 Sections Fig. 87	87*	None
	5	146 to 155	3 Sections Figs. 88 to 93	88*	All S.1, start of S.2
	6	156 to 159	2 Sections Figs. 94 to 97	94*, 97	Start and end of S.2
	7	160 to 162	3 Sections Fig. 98	98*	All S.1, centre of S.3
	8	162, 163	2 Sections Fig. 99	99*	End of S.2
	9	164 to 167	2 Sections Fig. 100	100*	Title, end of S.2
	10	168 to 170	2 Sections Figs. 101, 102	102*	Start of S.1, middle of S.2

Category	Chapter	Pages in new numbering	Original contents	Illustrations	Omissions	
					Text	
Cover		I	-	-	-	
Intro- duction		2 to 4	Same	-	-	
I	1	4 to 10, 69, 70, 11 to 30	10 Sections, Figs. 1 to 33	4*, 6, 7, 8, 10, 11, 13, 14, 15, 16, 18, 19, 20, 22 to 25, 28 to 33	End of S.1, centre of S.2, start and end of S.3, first few words of S.4, most of S.6 - only the start re- mains, all S.7, start and end of S.8, start and end of S.9	
	2	30 to 36	5 Sections Figs. 34 to 40	34*, 39, 40	Most of S.1 - only the start remains, first few words of S.2, last few lines of S.3, all S.4, most of S.5	
	3	59, 60 37 to 45	6 Sections, Figs. 41 to 47	41*, 42	All S.1, all S.2	
	4	45 to 68, 71 to 76	15 Sections Figs. 48 to 59	48*, 51, 52, 59	End of S.1, last few lines of S.5, all S.6, start of S.7, end of S.12, start of S.13, end of S.15	
	5	77 to 82	3 Sections Figs. 60 to 62	60*, 62,	Start of S.1, middle of S.3	
	6	82 to 95 (86 is a duplicate of 85)	6 Sections Figs. 63 to 70	63*, 66, 67	Most of S.1 - only start remains, most of S.3 - only start remains, and some lines at the end, all S.4	
	7	98, 96, 97, 99 to 103	3 Sections Figs. 71 to 74	74*	Last part of S.3	
	8	104 to 107	3 Sections Fig. 75	75*	Start of S.1, most of S.3 - only the start remains	

715, or December 1315. This is therefore the third oldest known copy of al-Jazari's work, being pre-dated by Topkapi Ahmet III 3472 and Topkapi H. 414. The list of Mss given by Hassan (*op. cit.* 60-62) brings up-to-date the the list in Hill 3-6. Of these fourteen Mss I have now examined the originals of eight, namely: Bodleian Library, Oxford, Graves 27 and Fraser 186; University of Leiden Or. 117 and Or. 656; Bibliothèque Nationale, Paris, Fonds Arabe 2477 and 5101, Suppl. Pers. 1145 and 1145a. I have also seen pages from Hagia Sophia 3606. I have photocopies of Topkapi Ahmet III 3472 and Chester Beatty Library, Dublin, No. 4187. I have yet to examine, therefore, Topkapi Hazime H 414 dated 672/1274, Topkapi Ahmet III 3350 dated 863/1459, and Topkapi Ahmet III 3461, date unknown. Hassan assesses the first of these three as a very good copy, the second as inferior with regard to the illustrations, and the third as uneven, with some sections poorly written and illustrated but most of it of good quality. Leaving aside the question of completeness, it seems that the 715/1315 manuscript can be ranked among the best. The calligraphy is excellent, the illustrations are very fine, and the text, though not without errors, is free from major blemishes.

The manuscript has Persian pagination, added at some time after the copy was made. Unfortunately, this pagination is unreliable: some pages are unnumbered, some are out of order, and in certain cases the lengths of the lacunae indicated by the gaps in the numeration do not match the lengths of the missing text. The expedient was therefore adopted of numbering the pages (*i. e.* *denüfolios*), starting with the cover, and then sorting the pages so numbered into order. This produced the following sequence: 1 to 10, 69, 70, 11 to 36, 59, 60, 37 to 68, 71 to 95, 98, 96, 97, 99 to 113, 130, 131, 114 to 129, 132 to 189, 265 to 268, 190 to 264, 269 to 296.

In the following analysis this new pagination is used, and the illustrations are given the Figure Nos. from Hill. In the right-hand column the abbreviation 'S' is used for Section. Al-Jazari provided one main illustration for each chapter and numbered them from 1 through to 50; these are marked with an asterisk.

Notice of an Important al-Jazari Manuscript

DONALD HILL*

This notice refers to a manuscript of al-Jazari's book on machines entitled *The Book of Knowledge of Ingenious Mechanical Devices*, or *A Compendium on the Theory and Practice of the Mechanical Arts*. It had previously been thought that the manuscript of this work dated 715/1315 had been completely dispersed; see, for example, Hill *op. cit.* p. 5, and Ahmad Y. al-Hasan in Vol. 1, No. 1 of this journal. Happily, this assumption proved to be incorrect, since about two thirds of the original manuscript, the property of the Hagop Kevorkian Fund, was included in Sotheby's Spring Islamic Sales on 3rd April 1978 in London. As reported in "The Times" of 4th April 1978, the manuscript was purchased by Messrs. Spink and Son of St James's, London for a little over £ 160,000. I would at the outset like to express my sincere gratitude to these two highly respected and responsible companies for the courtesy and co-operation that they have extended to me in the furtherance of my researches. Sotheby's gave me access to the manuscript before it was sold, and sent me a number of colour transparencies of the illustrations. I had fruitful discussions with members of the staff of Spink and Son, who provided me with a complete black-and-white photocopy of the manuscript. I am also very grateful to both companies for having given me permission to publish this paper, and to include in it, as I saw fit, any of the material that they so generously provided.

Some time ago a number of the illustrations were removed from the manuscript and found their way into various public and private collections. In my book I published twenty-one of these illustrations, these being all that I was able to trace. There are, however, 66½ illustrations missing from the manuscript sold by Sotheby's, so clearly a number remain undiscovered. Most of the lacunae in the manuscript can be accounted for by the removal of these illustrations, since either the accompanying demifolios of text or the surrounding text were removed with the illustrations.

The manuscript is written on thick polished paper, 314 mm. by 219 mm. to the page, in very fine *naskhi* script with 21 lines to the page. The colophon on page 207a (Persian pagination – see below) gives the name of the scribe as Farkh ibn 'Abd al-Laṭif and the date of his copy as the end of Ramaḍān

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"Much has been said about the composition of (books on) the art of medicine, and the part of it which is on therapy is dealt with far more than is necessary, (while) the theoretical part (is dealt with) far less than is necessary".

It is possible that the concentration of theoretical matter and the dearth of description of practical procedures rendered it less useful and so less popular than al-Majūsī's book. And hence, it never diffused to the West like the other book. The same fate seems to have befallen another *kunnāsh* written within 50 years of *K. al-Mi'a* and contemporary with al-Majūsī's book, perhaps for the same reason. *Al-Mu'ālaḡāt al-buḡrāṭiyya* is a large system of medicine in 10 *maqālāt* compiled by Abū'l-Ḥasan Aḡmad al-Ṭabarī,⁴⁹ the court physician to Rukn al-Dawla (932-976). This book has a similar arrangement of subject matter to *K. al-Mi'a* and deals with all the classical topics of medical theory. Diseases are likewise set out in the usual head-to-toe arrangement. The book is heavily biased towards theoretical discussion and is of high intellectual calibre. Relatively little attention is paid to matters of practical importance and it could not have had much appeal for the average practitioner. The author explains in the introduction to the book⁵⁰ that he has compiled it in order to salvage medicine from the hands of the ignorant and the superficial, and to return it to the tradition of the ancients he so admires. The result is not unlike *K. al-Mi'a*, except that it is perhaps less lucid and complete. This book likewise did not claim the attention of the Latin translators, nor was its author apparently known in the Latin West. In recent times, its fourth *maqāla*, which is on ophthalmology, was studied by Hirschberg,⁵¹ and some of its sections on diseases of the skin were translated into German by Mohammed Rihab.⁵² Otherwise, it has remained relatively unknown.

Despite these considerations, the question with regard to al-Masbūh's book must remain largely unanswered. It must be said in conclusion that the omission of this book from the mediaeval list of translations deprived the West of an important compendium, equally as valuable as al-Majūsī's *Kāmil al-ḡinā'a* and of the same calibre as Ibn Sīnā's *Canon*.

49. Some meagre facts about al-Ṭabarī's life are to be found in IAU, I 321. See also GAL I, 237. SI, 422.

50. There is a complete manuscript of this work in the Bodleian Library, Oxford, Marsh 158.

51. J. Hirschberg, *Geschichte der Augenheilkunde bei den Arabern* (Leipzig, 1908), pp. 167-114.

52. Mohammed Rihab, "Der arabische Arzt al-Ṭabarī. Übersetzung einzelner Abschnitte aus seinen 'Hippokratischen Behandlungen'." *Sudhoffs Archiv*, 19 (1927), 123-168.

territories. If they translated only what was available to them in Spain, then the choice of book was indeed dependent on its being present there. This raises the further question of why *K. al-Mi'a* was not available in Spain. In fact, as was noted earlier none of al-Masīhī's other books were translated into Latin either, nor does he himself seem to have been known to the Latin West. This is indeed a puzzle. Why, for instance, should 'Alī b. al-'Abbās al-Majūsī's *kunnūsh*, *Kāmil al-ṣinā'a* have been translated into Latin and not *K. al-Mi'a*?⁴⁸ These writers are quite comparable to each other: both were Persians and wrote their books in Persia within 50 years of each other. Thus, the problem of geographical diffusion should have been the same for both. The books are comparable in scope and style. Al-Majūsī's book is a large two-volume encyclopaedia on the whole of medicine, theory and practice. Like *K. al-Mi'a*, it discusses every aspect of medicine and classifies its subject-matter in the same thorough way. The accounts are of the same order of lucidity and precision. *Kāmil al-ṣinā'a* is likewise written with great authority. However, there is a difference between the two in the amount of space given to practice as opposed to theory. In this sense, *Kāmil al-ṣinā'a* is the more balanced, for half of it is on theory and half on practice, whereas, *K. al-Mi'a* is mainly devoted to theory, as has been shown above. This is in line with al-Masīhī's purpose in writing the book, for he says in his introduction:

ناقضى هذه العلم بحسب ما هو موجود عليه في هذه اما في حكمة فانه يرتب ويهيئ وينظم واما في
 جزء العمري منه فانه يضم ويصحيح واما في الاملاجات فانه يختصر ويعرب فقت هذه الشرط كلها وبدات النوع
 والصدق فيها فصرح اصبح واتم وانتهى واصغر ما امكن .

"This science, by its present nature, requires that it should be arranged in its entirety, simplified, and summarised. As to its theoretical part, this should be made complete and corrected; and as to its therapeutic part, this should be condensed and made more accessible. So I fulfilled all these conditions to the utmost of my capacity, and (the book) emerged more correct, complete, and easy to use, and as short as possible."

And further on in the introduction, he adds this:

فقد اكثرت الكلام في التصنيف وفي صناعة الطب والجزء الملاحي منه رائد على اقتدار الواحد بالمراد
 والجزء العمري قليل عن الواحد

⁴⁸ 'Alī b. al-'Abbās al-Majūsī lived and worked during the reign of the Persian ruler, 'Adud al-Dawla (949-982). Very little is known of his life (see IAU, I, 236. al-Qiftī, *op. cit.*, p. 232 GAL, I, 237. SI, 423). His book, *Kāmil al-ṣinā'a*, also known as *al-Kaṭīb al-Malaki* (because it was dedicated to 'Adud al-Dawla), was translated into Latin by Constantine the African as *Liber Pantegni* in the 11th century, and by Stephen of Antioch as *Liber Regius* in 1127, and enjoyed great fame and popularity in mediaeval Europe. (See Leclerc, *op. cit.* II, 359 and H. Schipperges, *Die Assimilation der arabischen Medizin durch das lateinische Mittelalter*, *Sudhoffs Archiv*, Beihefte, Heft 3, Wiesbaden, 1964, p. 35).

hyenas, and tigers, as many other *kunnāshāt* did, nor does it mention poisonous substances or medicines, as was also usual.

Comment

It should be clear from the foregoing description of contents that *K. al-Mi'a* is a large, comprehensive work which attempts to systematise the whole of medical theory. The major part of the book is devoted to theoretical considerations, and only a small part deals with practical procedures. There are no quotations from other medical authorities, a practice common to many *kunnāshāt*, where a quotation from an Arabic or Greek physician was often added either to lend support to the writer's opinion or to provide additional information on the subject under discussion. There may have been other reasons also.⁴⁷ The general style of the book is authoritative and it may be that the author's sense of his own authority made the inclusion of the sayings of others unnecessary. Be that as it may, it is easy to see why such scholars as Leclerc and Sarton saw *K. al-Mi'a* as a model for Ibn Sīnā's *Canon*. Its encyclopaedic range, extreme systematisation, and authority are indeed reminiscent of the *Canon*.

In a sense, it may have even been preferable to the *Canon*. For, the scholarship of the Middle Ages which was so inclined to favour rigid classifications and compact systems might well have welcomed the relative brevity of *K. al-Mi'a*. Furthermore, al-Masīhī's book is written in a lucid and didactic manner that would have made it of the greatest use to the mediaeval pedagogic tradition. It is extraordinary therefore to observe that al-Masīhī's encyclopaedia was not known to the Latin West.

This of course raises the unresolved question of why certain Arabic works and not others were translated into Latin. From the point of view of subject matter and form, *K. al-Mi'a* should have been ideal for the Latin mediaevalists. Its omission from their translations is difficult to explain. Of course, it is known that the bulk of translation from Arabic into Latin was carried out in Spain, and therefore the choice of material for translation must have been dictated in part by the availability of books in Toledo and other Spanish centres of translation. We do not know what efforts were made by the Latin translators, if any, to obtain books from elsewhere in the Islamic

⁴⁷ Such quotations have been of the greatest value to modern scholarship. For example, Ibn al-Jazār's book, *Zāid al-Munāfir* provided Daremberg during the last century with important fragments of Rufus' medical writings which he incorporated into his *Oeuvres de Rufus d'Éphèse* (ed. C. Daremberg and E. Ruelle, Paris, 1879). 'Alī b. Rabban al-Ṭabarī's *Firdaws al-ḥikma* (ed. by M. Z. Siddiqī, Berlin, 1928) contains a rich variety of quotations from Greek, Arabic, and Indian sources. Pseudo-Thābit's *K. al-Dhakhira fī 'ilm al-ṭibb* (ed. by G. Sobhy, Cairo, Government Press, 1928), also transmits many quotations from others.

on the uterus and on pregnancy. This is followed by a book "on the treatment of diseases special to men" and concerns inflammations and ulcers of the genital organs. But it also includes something on what may be termed "sexual medicine".⁴⁵ This is concerned with the ill effects of sexual over-indulgence and not with ways of increasing pleasure, as is to be found in the comparable sections of some other *kunnāshāt*.

The head-to-toe diseases end with gout and sciatica. The books after that are on external, or skin diseases. This includes the conditions affecting the hair such as alopecia and splitting of hair, and the disorders of the complexion like vitiligo, and the scars of smallpox and ulcers, as well as other skin diseases. Such a section on external diseases was a standard component of all *kunnāshāt*. It also included a certain amount on cosmetics: such matters as the dyeing and curling of hair, the removal of unwanted hair and remedies for purifying the complexion and changing its colour. The external disease part of *K. al-Mi'a*, however, has very little cosmetic emphasis and no directions for the dyeing or curling of hair. Book 99 is on fractures and dislocations. It is a short chapter and describes the general treatment of the body when a fracture takes place: this consists of evacuation and blood-letting in order to prevent the seepage of humours from the fracture site. There are some directions on how to correct dislocations and fractures and on binding the affected part.

But it is unlikely that such brief directions as are given would have been of much use to an orthopaedic practitioner. What is more likely is that, as this was a routine inclusion for most *kunnāshāt*, it was included here for the sake of completeness and does not necessarily imply that the author had ever practised any of the procedures he describes or that he intended them for practical purposes.

The last book is on another standard inclusion of *kunnāshāt*, namely, the bites of venomous animals: these include the snake, scorpion, tarantula, and wasp; there is also a chapter on the bites of rabid dogs, again a favourite subject with Arabic physicians. Snake and scorpion bites are treated, as might be expected, with the theriac, since theriacs were originally made up as antidotes, and it was only later that their use became widespread as universal panaceas.⁴⁶ The book does not deal with the bites of large animals, such as lions.

45. In Arabic literature, this phrase includes a number of related topics: the place of coitus in health; disorders associated with the performance of coitus such as impotence and priapism, gonorrhoea and nocturnal emission. The remedies in such sections often included numerous aphrodisiacs. Some books added chapters with a strongly erotic flavour on such subjects as ways of increasing sexual pleasure and sexual positions.

46. The theriacs were a group of compound medicines said to have been devised by the Greek physician, Andromachus, as antidotes against poisons of all types. By Galen's time, they were in use for other conditions as well, and later still, they became universal panaceas. See G. Watson, *Theriac and Mithridatum* (London, the Wellcome Historical Medical Library, 1966).

For example:

"Book 65: The treatment of diseases occurring in the organs of sensation and motion, that is to say the treatment of spasm, tetanus, flaccidity, numbness, and tremor".

"Book 79: the treatment of gastric evacuations, that is to say the treatment of cholera, dysentery, and lientery".

In general, the head-to-toe disease section of *K. al-Mi'a* is relatively short and relegated to a place of secondary importance. All chapters on disease are short and contain a cursory account of causes and symptoms. This is unlike the practice employed in many *kunnāshāt* of the time, where the head-to-toe diseases were given a place of pre-eminence as being the main subject matter around which the other principal subjects of medical theory were arranged. The reason for this departure in al-Masīhī's book is evident from the fact that he devotes considerable space to the theoretical principles underlying the causes and mechanisms of disease, symptoms, and therapy. Hence, when he comes to the description of actual disease entities, he is very brief on their specific features, having already explained their general characteristics at length.

The account of epilepsy is a typical illustration:

(f. 282, 1.4 - 1.11)

قد يكون من آفة مخصوصة بالدماع ويكون من مشاركة المعدة وبعض الاطراب كالحمل او اليد او مشاركة الرحم لسانه بأن يصمد من كل واحد من هذه الاعضاء ما يسد سبيل بطون الدماغ تحدث الصرع كما كان يصمد من بعض الاطراف فيسفي في وقت البوة قبل ظهورها أن يشد فوق ذلك الموضع برمايد شداً محكمًا الى أن تنقطع البوة ثم يظل الموضع بالمفعل والمردل والمرفيون وعسل اللادر ويرك حتى يسقط

"(Epilepsy) may occur from a malady specific to the brain, or it may occur in association with the stomach and some of the extremities, such as the leg or the hand; or because of association with the womb in women. Thus, something ascends from each of these organs which obstructs the apertures of the ventricles of the brain and so epilepsy occurs. If it ascends from one of the extremities, it will be necessary at the time of the fit and before it happens to bind (the part) above that place with a firm, tight bandage until the fit is stopped. Then the part should be painted with pepper, castor, euphorbium, and anacardium honey, and left until it blisters".

It will be readily seen that there is no clinical description here. The rest of the chapter is concerned with therapy, which is given in some detail.

The list of diseases described goes down through the body in descending order. After the books on diseases of the urinary tract, there is a short section

significance, (this is to be differentiated from prognosis, which is the subject of book 54), the periods of disease, meaning the four stages of disease as classified by Greek and Arabic physicians: commencement, increase, culmination, and decline; and the three cornerstones of mediaeval disease theory: coction, crisis, and critical days. The subjects are dealt with in characteristically detailed and lucid manner, and the accounts are exactly in line with the earlier Greek teaching and with the other Arabic books on the same theme.

There are three books on the preservation of health. These include the healthful regimen to be adopted at various ages. Attention is to be paid to the diet, sleep, movement and rest, baths, massage, psychical events, and the ambient air - in other words, to the six non-naturals. This matter was a regular component of Arabic *kunndshât*, and was also treated as a separate subject, as the many Arabic tracts on hygiene testify.⁴⁴ Book 59 is on the principles of the treatment of diseases, and contains a clear statement of the physician's function with regard to disease and its management:

(f. 267a, l. 12 - 1.14)

دلتب فاعل كالمب الطيبة بأى يقرب منها الدواء ويعبر من داخل أو خارج على ما يسمي في الوقت
والمقدار فهو يحمر بحصول ما تنقوى به فتعين به في دفع المرض ولذا كانت نصيحة قد تدفع وتريل
كثيرا من الأمراض من دون دواء أو طبيب وليس يقدر الدواء ولا الطبيب بدالة المرض البتة متى حارث القوة
ومعجزت

"The physician acts as an assistant to nature, in that he brings to it medicine and other things either internally or externally, in the correct amounts and at the correct times. For he aids (nature) to attain what strengthens it and assists it in repulsing the disease. In this way, nature repulses and eliminates many diseases without either medicine or physician, nor can either medicine or physician eliminate a disease once the strength has collapsed and become impotent".

Thus, here is a clear adherence to the Hippocratic attitude with regard to the importance of nature and to its standing as the real physician. There is then a detailed and highly systematic account of the things which have to be taken into account when deciding on the correct treatment. It is only at this point in the work that practical directions as to the management of specific diseases are given, but even then, there is little emphasis on therapeutic detail. The next series of books represent the head-to-toe disease section of the book. There is an unusual tendency to classify some diseases according to functional and pathological considerations rather than on the basis of pure anatomical site.

⁴⁴ Qusfâ b. Lûqâ, Ishâq b. 'Imrân, Ibn Sînâ, Ibn al-Mu'tarr, and many others wrote separate tracts on hygiene.

The function of air is to be a cooling agent for the heart, which is conceived of as a furnace wherein the innate heat burns. The lung therefore acts as a bellows to cool the heart. Thus,

(f. 216b, 1.10 – 1.14)

فصارب الرئة تيسر وتعدس باسقاط الصدر وانعاضه ومي سمعت مثلثت تحددبها هوا، ومي
انقيصت اندفع لي حارج ما اندفع اليها من دخان القلب فالتنفس هو سب حصول الهواء للقلب الذي به يتروح
اولا وتهدى حرارته بمقدرة نقية وتكون من الروح الجوفى الذي يوسعه نقل قوة حادة واخرارة بمرارة
الى جميع البدن

"The lung expands and contracts with the expansion and contraction of the chest. When it expands, its cavities fill with air, and when it contracts, the smoke of the heart which has been expelled to it is expelled to the exterior. For respiration is the means whereby the heart obtains the air with which it is fanned and (hence) its heat remains moderate and pure, and from which is created the animal spirit by whose agency the life force and the innate heat reach the rest of the body".

These ideas on respiration are very similar to the ideas expressed by Aristotle and Galen, in particular the concept of the bellows and the burning furnace wherein combustion takes place, and hence the need to expel 'the smoke of the heart'.⁴³ The next 9 books deal with 'pathology', for they concern the pulse, the urine, and faeces, and their features in health and disease.

The book on the pulse is complicated and detailed. Pulse lore was a most important aspect of the Arabic medical system. Arabic physicians routinely described 10 kinds of abnormal pulse. These went under certain names, such as the "mouse-tail pulse" and the "gazelle-like pulse", and their patterns were intricately described. This seems to have been a theoretical artifice more than anything else, and it is doubtful whether anyone actually ever felt most of what was described. Of no less importance was the subject of the urine. Al-Masīhī goes into the matter of uroscopy at length and in great detail, with great emphasis on its pre-eminence in the art of medicine. He explains how urine is formed from the watery part of blood and stresses that its examination will give information about many internal conditions. The different kinds of pathological urine are described, which, like the kinds of pulse, were common to all Arabic medical writing.

The following books deal with several important subjects: on the anticipation of illnesses by warning signs, which was a review of signs of prognostic

⁴³ There is a similar description in Aristotle's *De Respiratione*, transl. by W.S. Hett, Loeb Classical Library, (London, Heinemann, 1957), p. 479, and at greater length in Galen's *On the Usefulness of the Parts*, op. cit., 1, 316.

latter survives only in Arabic translation.⁴¹

The subsequent books have detailed discussions on the signs of psychical ailments, on secretions evacuated from the body, and on fevers. The book on fevers is devoted to the theoretical understanding of the nature and differentiation of fevers. He defines fever as a contranatural heat; the site of this heat in the body determines the type of fever it is, as follows:

(f. 194a, l. 15 - f. 194b, l. 2)

فمن كانه في الارواح كانت حتى يوم وهي سففي اذا في يوم واحد وإما في موة واحدة إنا بقى
أكثر من يوم واحد وهي كانت في الاحلاط كانت حتى الموية وحتى الموية بها ذنم. وهي التي مذهب
محصورة في المروق وسها ذات افتراق وروب وهي التي مذهبها حارحة عن المروق وهي كانت في الاعضاء
كانت حتى الدق

"When the heat is in the spirit, it is an ephemeral fever; it goes either in one day or in one paroxysm. If it stays for longer than one day, and when (the heat) is in the humours, then it is a putrid fever. Putrid fever may be continuous, and that is when its matter is confined to the veins, or it may have periods and paroxysms, and that is when its matter is outside the vein. When (the heat) is in the organs, it is a hectic fever."

His account of fevers follows this pattern and makes the subject, which must have posed the physician of the time the greatest diagnostic difficulties, seem simple and straightforward. Book 41 is on the signs of diseases of various parts of the body. The next book gives an account of the signs of the temperaments. This describes the signs of a hot, cold, wet, dry temperament, and compounds of these (i. e. hot-dry, cold-wet, etc.), and how the temperament may be diagnosed from the colour, the facial expression, the touch, and the actions. The temperaments of organs are also included. There is a section on the indications from the facial features, the teeth, the nails, and the skin as to the temperament (for example, a hairy chest indicates a hot temperament of the heart). This science, (physiognomy, Arabic: *al-firāsa*), was a most important subject in Arabic medicine. Al-Rāzi has a large section on it in his *K. al-Manẓūrī*, and several Greek works on the subject were available in Arabic translation from the time of Hunayn b. Ishāq.⁴²

Book 44 is on respiration and forms a compact and interesting account of the physiology of respiration of the time. There is a reiteration of the doctrine of spirits and a discussion of their entry and elaboration in the body.

41. This tract has been translated from the Arabic by M. C. Lyons as *On the Cohesive Causes*, in *Corpus Medicorum Graecorum Supplementum Orientale*, II, (Berlin, Akademie-Verlag, 1969).

42. Notably, the book on physiognomy of the Greek sophist, Polemo, which survives only in Arabic translation as *K. iftimūn fi'l-firāsa*. The material here is very similar to that in *K. al-Mi'a*.

and urine are also listed here. Book 32 continues an account of drugs classified according to their qualities, degrees, and special effects, that is, under "heating medicines in the first degree", there follows a list of substances; under "those medicines which attract the humours", another list of substances, and so on.

Book 35 discusses the classification of diseases, their causes, and their signs. As if by way of introduction, al-Masīhī explains something of the nature of all diseases:

(f. 164b, l.15 - 1.20)

وإن الأمراض وأسباب وأعراضها كلها أمور خارجة عن الطبع وعرض صفة الطب هو إزالتها كلها عن الفصد الأول فإن الذي يقصد إلى إزالته أولاً هو المرض لأنه هو الذي يضر بالعن لا أنه لا يروى إلا برواى السبب الذي أحدثه

"Diseases, their causes, and their symptoms are all contranatural matters. The purpose of the art of medicine is to remove them all, in order of priority. For (although) that which it is intended to remove first is the disease, because it is what is harmful in fact, (yet) it will not be removed unless the cause which has brought it about is removed (first)".

There then follows a classification of diseases according to the four primary qualities with examples to illustrate each type, and according to the compounds of the primary qualities, and whether these are accompanied by matter or not. As to the causes of disease, he classifies them and explains these in this way:

(f. 167b, l.15 - f.168a, l.1)

واسباب الأمراض ثلاثة أحاسن أحدها حسن الأسباب الدائمة والثاني حسن لأسباب السائمة والثالث حسن الأسباب الوصفية والأسباب الدائمة هي التي تؤثر في البدن وهي خارجة عنه من حرارة الشمس القوية التي تولد الحمى وإذا الأسباب التي تؤثر في البدن من داخل فما كان يبه ورس المرض سبب آخر فهو سبب سابق وما كان منها ليس يبه وبين المرض سبب آخر فهو سبب واصل

"The causes of disease are of three kinds: the first is that of the immediate causes; the second is that of the antecedent causes; and the third, that of the connecting causes. The immediate causes are those which affect the body (but) are external to it, like the strong heat of the sun which gives rise to fever. As to the causes which affect the body from inside, if there is a connection between them and the disease, then it is an antecedent cause. But if there is no (causal) connection between the disease and one of them, then that is a connecting cause".

This classification is in fact very similar to the Galenic classification of the types of causes, as explained in his tract *De Causis Continentibus*. The

Books 30 to 34 are concerned with the faculties of medicines and their classification. The subject of medicines was of the utmost importance to mediaeval physicians. Here is a clear exposition of the theoretical approach to the use of medicines in terms of their qualities and their special actions, whether purgative, diuretic, emetic, and so forth. The author encourages the use of "empirical medicines", (*mujarrabât*), but stresses that where possible, only one drug should be used at a time. These *mujarrabât* are of some interest; many books were devoted to this subject during the Arabic period, including those by al-Kindî, al-Râzi, Ibn Sînâ, Ibn Zuhri, Ibn al-Tilmidh and many others. Sarton³⁷ was very impressed with the tradition of *mujarrabât*, and held that it represented the earliest example of an experimental method in medicine. But in fact, the *mujarrabât* were nothing to do with the experimental method but were rather medicines which had been found to work by experience.³⁸ Many of them had obvious magical associations, particularly in the later writings of the 14th century and onwards.

The book on simples classifies them in alphabetical order, using the earlier type of Arabic alphabet (which follows the Hebrew order). Under each medicinal herb, there is a definition of its properties according to degrees from 1 to 4. Thus, a medicine is described as 'cooling in the first degree' and 'drying in the fourth degree.' Its special effects and properties, diuretic, purgative, binding, etc. are then listed. For example,

(f.135 b, l.6 - 1.8)

أبون ورد في الرابعة يابس في الثانية ينع من لاورم الحارة لطفه حار من من يجلب السات من
لحسن فيه ينع في تسكين الأوجاع والتخوم وكثيره يقتل

"Opium is cold in the fourth (degree), dry in the second; efficacious in hot, inflamed swellings, especially of the eye; causative of lethargy. anaesthetic; a small amount of it is efficacious in stilling pain and for narcotics; a great deal of it kills."

This system of degree classification was a refinement of the Galenic arrangement whereby drugs were graded according to their qualities and their efficacy.³⁹ The Arabic physicians broadened and expanded Galen's ideas into a neat and well-ordered system.⁴⁰ Parts of animals are also included here as substances with medicinal properties, as for example with the livers of certain animals, which are used as sympathetic medicines in diseases of the liver. The gall, tongues, and secretions of animals, such as their saliva, milk,

37. Sarton, *op. cit.*, II, 94.

38. In this, one must agree with Ullmann who takes issue with Sarton in his special section on *mujarrabât*, (*Die Medizin*, *op. cit.* pp. 311-3).

39. For a study of the Galenic system of drug classification, see G. Harig, *Bestimmung der Intensität im medizinischen System Galens* (Berlin, 1974).

40. Al-Majūsî devotes a large section of his book (*op. cit.* above) to this classification of drugs.

al-Mansûri, is almost identical),³³ to the extent of repeating Galen's erroneous assertion that there were communications between the right and left ventricles. It was this assertion which was countered by Ibn al-Nafis two hundred years later, and which earned him the enthusiastic description of "the discoverer of the pulmonary circulation" by certain modern writers.³⁴ The next book is also Galenic in concept, for it contains a teleological account of the function of organs on the lines of the large work of Galen, *On the Usefulness of the Parts of the Body*.³⁵ There is much useful information in this book on the physiology of the time, and a remarkably clear exposition of the role of the vital heat and the elaboration of the animal spirit.

The books that follow may be said to be about the environment: on airs and winds, on dwellings, and on waters. Books 12 to 18 inclusive are on dietetics: the principles governing the choice of food and drink which are connected with a study of the temperament, the season, and the preponderant humours; the faculties and qualities of simple foods; and the benefits and properties of wine and other drinks. Book 16 deals with the healthful preparation and cooking of food, and explains that foods are classified as digestible, indigestible, high in superfluous, or low in superfluities, and the like.

The next few books deal with the non-naturals. On the subject of evacuation, there is a lengthy book devoted to blood-letting, its advantages and disadvantages, the indications for blood-letting, and how much blood to remove. It ends with a detailed and fascinating account of the technique of blood-letting, what instrument to use, what shape incision to make, whether along the length or width of the vein, and what to use to keep the vein patent. Al-Masîhî's contemporary in Spain, Abû'l-Qâsim al-Zahrâwî, also left a long and detailed account of the technique of venesection and its indications.³⁶ Book 29 is on the signs of psychical origin, such as grief and anger. The observation is made here that anger leads to a yellow complexion, due to an increase in yellow bile. This brings to mind the use in this connection of the English word "choleric" and its obvious humoral origin.

33. For comparison see Galen's description of the heart in his *On Anatomical Procedures*, transl. C. Singer, Wellcome Historical Museum Publications, (Oxford University Press, 1956), VII, 175, 179-188. The anatomy of the heart is given in *maqâla I* of the *K. al-Mansûri*, "On the form and appearance of organs".

34. See M. Meyerhof, "Ibn al-Nafis (XIIIth century) and His Theory of the Lesser Circulation" *Ist.*, 23 (1935), 180-20.

35. Transl. by M. T. May, Cornell University Press, 1968.

36. *Albucasis on Surgical Instruments*, ed and transl. by M. S. Spink and G. L. Lewis, (London, Wellcome Institute for the History of Medicine Publications, 1973), pp. 624-655 (on veins), and pp. 174-183 (on arteries).

This extract displays the general style of the book quite well. It also reveals the neat systematisation typical of Arabic writers. This economy of description of the faculties should be compared with the prolixity and disorganisation of Galen's work on the same theme, *On the Natural Faculties*.³¹ The other books on the temperaments, the actions, and the spirits are just as well-ordered and provide a thorough review of the principles of medical theory in readily assimilable form.

The two books on the like and unlike organs constitute the anatomy section of the work. These terms refer to the classification of the parts of the body into those whose constituents are homogenous, such as fat, bone, cartilage, and so on, and those which are made up of different tissues, such as arms, legs, hands, and so on. This division was common to Arabic anatomy, and derived from an Aristotelian classification of the organs of the body into 'homeomerous' and 'anhomeomerous' types.³² The unlike organs are classified from top to bottom, in the same way as diseases, and in fact represent the internal organs. The anatomical descriptions are exact, as for instance this extract on the heart:

(f. 21b, 1.6 - 1.12)

ونقلب صوري الشكل قاعدته في جهة عالي البدن ورأسه المحرووط ان جهة أساس البدن وقاعدة القلب موصوفة في وسط الصدر ومن جميع جهاتها ورأسه المحرووط مائل إلى ناحية اليسار والقلب ثلاث من عظام كتف محيط به، تسمى رأسه إلا منه قاعدته وفيه نحوها من العظام في اجانب اليمين والآخر في الجانب الأيسر وفي التجويف الأيمن الدم أكثر من الروح وفي الأيسر الروح أكثر من الدم ومن لا يمين في الأيسر مصادق بطبيعته.

"The heart is cone-shaped, its base being towards the top of the body, and its pointed end towards the lower part of the body. The base of the heart is in the middle of the chest (equally) on all its sides, (but) its pointed head is inclined towards the left side.

"The heart has an envelope made of a thick membrane, which surrounds it but is distinct from it (i. e. not adherent) except at its base. It has two cavities, one on the right side and one on the left. There is more blood than spirit in the right cavity, and more spirit than blood in the left. There are small apertures from the right to the left (cavity)"

This description is interesting in more ways than one. It is modelled on Galenic anatomy, like other Arabic books of the time, (for example, the section on the anatomy of the heart in al-Rāzī's famous *kunnāsh*, K.

³¹ Translated by A. J. Brock, Loeb Classical Library (London, Heinemann), 1928.

³² Cf. Aristotle. *De Partibus Animalium*, 646b, 11-20, in *The Works of Aristotle*, ed. and trans. by W.D. Ross (Oxford University Press, 1910-49). This section includes a discussion on the "homeomerous" and the "anhomeomerous" parts.

black humour go beyond the nature of blood, because they have reached the limits of combustion. The presence of all these in the body is normal, meaning that blood is the true nutrition that is intended and phlegm is a humour which could be digested so that the body could be nourished by it".

And still on the subject of humours, al-Masīhī explains how it is that they cause disease:

(f. 30b, 1.12 - 1.15)

وهذه هي الاطلائ التي تسمى اركان البدن وأما إذا زادت على هذا القدر أو الكيفية فحارجه عن الطبع
لسبب مرضي ويجب ان تمدد ان كانت مفرطة الكيفيات وتسترع ان كانت كثيرة المقدار

"There are the humours which are called the fundamental components of the body. But if they increase over their (normal) amount or their qualities, they become contra-natural due to a pathological cause. It is (then) necessary to bring (the body) back to a state of moderation if (the humours) are in excess in their qualities, and to evacuate it if they are excessive in amount."

In this brief extract, he enunciates the principles of disease causation and therapy which were the essence of the humoral theory followed by himself, his contemporaries, and the Greek physicians before him. As to the other aspects of the humoral theory, the faculties are explained in a systematic manner:

(f. 36a, 1.14 - 1.22)

فإن البدن اربع قوى اعدادها بصفاته وهي التي تعمل الاحساس والتشخيص والتحريك بالاحتياج والاشية
حماية وهي تعطي جميع البدن الحياة والحرارة المريرة والثالثة طبيعية وهي التي تعطي حركه الدم الغذاء
وتدفع فضولاته والرابعة مولدة وهي التي تمد الزرع وتكمل الحرس وقد تعد في صنعه الطب القوة المولدة مع
القوة الفادية ويسمى جميع ذلك الطبيعية

"The body has four faculties, the first is psychic and it is (the faculty) which effects sensation, discrimination, and voluntary motion. The second is animal and it is the one which gives life and the innate heat to the whole of the body. The third is natural, and it is the one which gives the whole of the body nutrition and which expels its superfluities. The fourth is generative, and it is the one which prepares for fertilisation and which completes the growth of the foetus. In medicine, the generative faculty is counted with the nutritive faculty, and the two together are called the natural (faculty)".

The first book is a highly theoretical and philosophical introduction to medicine. The second book presents a lengthy account of the theory of elements and how they enter into the formation of the human body:

(f. 6b, 1.17 – f. 7a, 1.12)

والاجسام الاول باطبع اربعة النار والهواء والماء والارض وإما سميت اجساما أوليا لاجل لا تتركب ولا تتكون من اجسام أخر غيرها . والبدن مركب من الاعضاء امتشابه الاحراء وكل واحد من هذه قد يكون إما اوليا في امي وإما من بعد ذلك في الدم والملي يتكون من الدم والدم من الغذاء والغذاء من الحبوب وإما نبات وحبوب حال هذه كحب البن الاسود وذن كلها من النبات والنبات يتكون من الارض وأما ما يدعى بدن الاصل مركب من الاقطعت الاول .

"The elements in nature are four: fire, air, water, and earth. They were named elements because they are not constructed or formed from any other bodies. . . and the (human) body is made up of organs of like parts. Every one of these (organs) exists either in the semen first or in the blood after that. And the semen is formed from blood, and blood (is formed) from food, and food is either animal or plant. The state of an animal's body is like that of man, so, therefore, all of them come from plants; and plants are formed from earth and water. Therefore, the body of man is made up of the primary elements".

He goes on to define the qualities of the four elements as hot, wet, dry, etc. His style is clear, didactic, and detailed. The other sections on medical theory are likewise lucid. The book on the humours, for example, could not have left any student of the art in much doubt as to the nature of the humours in health and disease:

(f. 28a, 1.1 – 1.11)

والاحلاط وهي رمة الدم واخلط الأحمر والخلط الاسود والبلغم وخصولها كلها في البدن بسبب الغذاء بمعنى أن بعضها غذاء وهو الدم وبعضها فضولات الغذاء . وهي ثلاثة الاحلاط الاربعة لأن البلغم فضلة تتولد من الدم لأن الغذاء لم يهضم ولم ينضج فبقي على صورته والخلط الاصفر واخلط الاسود مجاوران لطبيعة الدم لاجل قد صار في حد الاحراق ووجودها كلها في البدن طبعي بمعنى أن الدم هو الغذاء الحقيقي المتقصور والبلغم خلط يمكن أن يهضم فيقتضي به البدن .

"The humours are four: blood, the yellow humour, the black humour, and phlegm. They are all to be found in the body by reason of food, meaning that some of them are food, and that is blood, and some are superfluities of food; these are the three remaining humours, for phlegm is a superfluity which comes before blood because the food has not been digested and has not reached coction yet, so that it stays unripe. The yellow humour and the

and external diseases. The external diseases section here is subdivided into diseases of the scalp, the skin, and the skin colour. Two other topics, which were also very commonly included in medical compendia, although not uniformly so, appear: fractures and dislocations, and venomous bites. Several books are devoted to the subject of medicines both, simple and compound, matter of the highest importance in any medical book.

Subjects of Books in K. al-Mi'a

Introduction to medicine	Psychical ailments
The elements	Secretions evacuated from the body
The homeomerous organs	The types of fevers
The unhomeomerous organs	Swellings
The usefulness of the parts of the body	The signs of diseases of various parts of the body
The humours	Respiration
The temperaments	The pulse
The faculties	The urine
The actions	The faeces
The spirits	Premontory signs
The natural states of the body	Periods of disease
Airs and winds	Coction
Dwellings and waters	Crisis
Faculties and qualities of foods	Critical days
Drinks and wines	Favourable and unfavourable signs
Sleep and waking	The signs of disease
Massage	The preservation of health
Movement and rest	Principles of treatment of diseases
Baths	The treatment of fevers
Purgation	The treatment of swellings
Emesis	The treatment of ulcers
Venesection	Diseases from head to toe
Diuresis	Pregnancy and diseases of the uterus
Perpiration	Diseases special to men
Gargling	Diseases of the hair
Clysters	Scars of ulcers
The signs of psychical origin (grief, anger, etc.)	Disorders of skin colour
Faculties of medicines	Diseases of the skin
Simple	Fractures and dislocations
Medicines with special properties	Bites of venomous animals
Causes and signs of disease	

are not properly organised, so that the divisions of the art are not known; there is either too much detail or too little; theory receives too little attention, while practical methods and therapy receive too much. For these reasons, the author has decided to write a book which will remedy all these failings in as synoptic a way as possible.

The result is an encyclopaedia of medicine in which everything is systematised as far as possible. It is organised on a basis of the standard divisions of medicine, (best expressed in Hunayn b. Ishāq's pithy introduction to medicine, *al-Masā'il fi'l-ṭibb*).²⁸ The descriptions are lucid, well-ordered, and there is indeed an attempt to make each book complete in itself. There is a strong emphasis on theoretical aspects, and indeed the major part of the book is devoted to theoretical principles and discussion. It is only when the 60th book is reached on f. 267b, that is, after two-thirds of the book have been gone through, that practical methods are included in any detail.

The index of "books" is set out soon after the introduction. Each section is named "the book of such-and-such." The subjects dealt with in these books have been listed on the following page. They do not correspond to the actual titles in *K. al-Mi'a*, where the same subject sometimes has several books devoted to it, but are meant here to convey a general idea to the reader of the contents of the *kunnāsh*. In this way, it may be seen that all the standard topics in medicine which were current at the time are covered: all essential aspects of the humoral theory, the naturals: which are the organs, the elements, the temperaments, the faculties, the actions, and the spirits; the non-naturals,²⁹ which are six and which may be picked out among the list of subjects early on in the *kunnāsh* as air, food and drink, sleep and waking, movement and rest, evacuations (detailed into purgation, emesis, venesection, and the like), and the passions of the soul (the signs of psychical origin); and the contra-naturals, meaning the cause and process of disease. There is a section on 'pathology', that is, coction, crisis, the pulse, and the urine; a section on prognosis; and a section on the preservation of health. All these were standard subjects of importance which were included as a matter of routine in most *kunnāshāt*. Likewise, there is the inevitable classification of diseases from head to toe,³⁰ and the other two classical subjects, fevers

28. This work, alternatively known as the *Isagoge*, was celebrated throughout the Middle Ages. It is set out in a question-and-answer form and summarises the medical theory of the time using a rigid classification of subject matter which became standard for all medical books thereafter. (This important work is still unedited and exists only in manuscript form.)

29. There are several studies on the non-naturals. For example, P. H. Neibyl, "The non-naturals", *Bull. Hist. Med.*, 45 (1971), 486-92, and L. J. Rother, "The six things non-natural, a note on the origins and fate of a doctrine and a phrase", *Clio Medica*, 3 (1968), 337-47.

30. This was a classification that was universally employed in Arabic medical textbooks and in the Greek medical books of late antiquity.

well written, and provided a wide selection of treatments.²¹ It was recommended for use by students in the medical teaching syllabus of the *Chahār Maqāla*, as was noted above. Modern commentators have also been impressed with this book: both Leclerc and Sarton believed it to have been a model for Ibn Sīnā's *Canon*.²² The book survives in at least 29 manuscript copies. The earliest of these is said to be to be dated 400/1010, which, if true, means that it must have been made either during the author's lifetime or shortly after his death.²³ There are six other early manuscripts, that is, dating from before 1300 A.D.²⁴ In the centuries that follow, there are manuscripts dating from each century, and a high concentration of very late manuscripts: five are said to be dated between 1233/1818 and 1300/1883.²⁵ Thus, manuscripts survive from every century beginning virtually from the date of death of the author until the end of the last century. This, and the large number of surviving manuscripts is impressive evidence of the popularity and importance of the book.

In the account that follows, only the briefest summary of the book's contents has been given, for it is such a large and comprehensive work that it could (and should) form the subject of a much longer study.

Contents of K. al-Mī'a

K. al-Mī'a is a large work: the British Library manuscript, on which this study is based, contains 376 folios of small script.²⁶ It is divided into a hundred chapters or "books", (hence the title), and, as the author says in his introduction, each is meant to be a complete work of its own, not dependent on the others for its understanding. The introduction is long and contains an analysis of the problems which beset the writing of medical books:²⁷ they

21. This information is supplied by IAU. I. 328. Amīn al-Dawla b. al-Tilmidh was a distinguished physician of the 12th century. (d 1165), who was chief physician at the 'Aḡḡḡ hospital in Baghdad. (For his biography, see IAU. I, 259-76).

22. Leclerc, *op. cit.*, I, 356-7; Sarton, *op. cit.*, I, 678.

23. This MS., Istanbul, Nuruosmaniye 3557, is described by Dietrich, (A. Dietrich, *Medicinalia Arabica*, Göttingen Vandenhoeck and Ruprecht, 1966, p. 70). The dating is only presumptive.

24. The manuscript citations for these are to be found in GAL, I. 238. SI, 423; and Sargis, *op. cit.*, III, 326-7.

25. The most recent is MS. Tehran, Danishkada-1 Pishiki, 247/1.

26. This is MS. Or. 6489. It is dated (on f. 194a) as 1105 A. H. (1694 A. D.) and is written in clear, good naskh. It is well preserved but part of the introduction is obliterated and some of the folios of chapter 99 on fractures and dislocations are missing. (See also S. Hasmareh, *Catalogue of the Arabic Manuscripts on Medicine and Pharmacy at the British Library*, Cairo, "Les Editions Universitaires d'Egypte", 1975, pp. 88-90).

27. This was a common format for introductions to compendia of medicine. There was always some fault with the others which the author had decided to rectify in his book. A lengthy critique of other *kunnāshāt*, both Greek and Arabic, is to be found in the introduction to al-Majlisī's *Kāmil*.

b. Muḥammad (992-1009). (the father of Abū'l-ʿAbbās Ma'mūn b. Ma'mūn mentioned above). Al-Bayhaqī¹³ also links al-Masīhī with this ruler, for he says that the patron of al-Masīhī was the king of Khwārizm, Ma'mūn b. Muḥammad, to whom he dedicated another of his works, *K. Ta'bir al-ru'ya* ("the interpretation of dreams").

As to his dates, there is the usual difficulty with determining these exactly. Wüstenfeld,¹⁴ who describes him as the teacher of Ibn Sīnā, gives his date of death as being around 390/1000, though on what evidence is not clear. Sarton¹⁵ gives a similar date, saying that al-Masīhī died aged 40 in 999-1000. Leclerc,¹⁶ likewise, puts his date of death at 1000. (It should be pointed out that all these authorities, presumably following Ibn Abī Usaybi'a, state that al-Masīhī was Ibn Sīnā's teacher). Brockelmann,¹⁷ however, gives the later date of 401/1010, as does Ullmann.¹⁸ Sezgin¹⁹ cites a manuscript of one of al-Masīhī's works which is dedicated to Abū'l-ʿAbbās Ma'mūn (1009-1017). If this is indeed the case, and the book was not in fact dedicated to his father (as noted above on the authority of al-Bayhaqī), then the later date will have to be accepted. It is certain at least that al-Masīhī was alive in 1002, for it is known that Ibn Sīnā dedicated a missive to him from Jurjān in that year.²⁰ From this information, all that can be said is that al-Masīhī was alive in 1002 and died some time after 1009.

Kuḏb al-Mi'a fi'l-Ṭibb

Seven works of al-Masīhī's survive: the best known is *K. al-Mi'a*. It was considered by the famous physician Ibn al-Tilmīdh, who wrote a gloss on it, to have been of the greatest value because it was exact, not repetitious,

13. Zuhūr al-Dīn al-Bayhaqī, *Ta'rikh ḥukamā' al-ʿislām*, ed. M. Kurd 'Alī, (Damascus, Maṭba'at al-Tarāqī 1946), pp. 88-9.

14. F. Wüstenfeld *Geschichte der arabischen Ärzte und Naturforscher*, (Göttingen, 1840), p. 59, No. 118.

15. G. Sarton, *Introduction to the History of Science* (Baltimore, Williams and Wilkins, 1927-48), I, 678.

16. L. Leclerc, *Histoire de la Médecine Arabe*, (Paris 1876), I, 356-7.

17. C. Brockelmann, *Geschichte der arabischen Literatur*, (henceforth: GAL) and *Supplement* (henceforth: S), (Leiden, Brill, 1937-42), I, 238; SI, 423.

18. Ullmann, *op. cit.*, p. 151.

19. F. Sezgin, *Geschichte der arabischen Schriftums* (Leiden, Brill, 1967), III, 327, No. 6, *Risāla fi taḥqīq ḥik' al-mi'aj mā huwa wa kam aynafuḥu*, MS. Shehād Ali, 2095/5.

20. IAU, II, 19, 1.10-11, lists this among Ibn Sīnā's works. "A missive to Abū Saḥl al-Masīhī on the angle, which he wrote in Jurjān" It may be calculated from Ibn Sīnā's autobiography, (*The Life of Ibn Sīnā*, ed. and transl. by W. E. Gohlman, (State University of New York Press, 1974), that he was in Jurjān in 1002.

He describes him as a "practitioner" (*al-mutaʿabbib*) and a logician (*al-mantiqī*), presumably implying by the latter description that he was interested in or had written works on logic. He wrote a famous *kunnāsh* called *al-Miʿat maqāla* (more usually known as *Kitāb al-miʿa fiʾl-tibb*). He died "in middle age" at the age of 40. Ibn Abī Usaybiʿa is able to give more information about him:⁸ he praises his skill as a physician and his great learning and stresses his fluency and excellence in the Arabic language, which he wrote with a beautiful hand. Ibn Abī Usaybiʿa says that he examined a copy of al-Masīhī's book, *Fi Ighār hikmat Allāh taʿāla fi khalq al-insān* ("On the Revelation of God's Wisdom in Creating Man"), written in his own handwriting, and was impressed by its excellence of grammar and linguistic precision. He goes on to report what Shaykh Muḥaddhab al-Dīn ʿAbd al-Raḥīm b. ʿAlī said of al-Masīhī: he had never known any Christian physician, either ancient or modern, who could express himself as well as al-Masīhī. (All this implies that al-Masīhī's first language was not Arabic, and since he was a Christian, his mother tongue might well have been Syriac; it also implies that Christians in general did not know Arabic well). Then, Ibn Abī Usaybiʿa says that al-Masīhī is said to have been the teacher of Ibn Sīnā in medicine, and that the latter became proficient in this and in philosophy at his hands, such that he dedicated several books to him.

It is not by any means certain that al-Masīhī was indeed Ibn Sīnā's teacher. Ibn Sīnā himself asserts in his autobiography that he had no teachers in medicine,⁹ not that that necessarily rules it out completely. But al-Qifī makes no mention of this claim either.¹⁰ The two men are, however, connected in the Persian 12th-century work, the *Chahār Maqāla*, where the story is recounted that when both of them took flight from the court of the ruler of Khwarizm Abū'l-ʿAbbās Maʾmūn (1009-1017), they were overtaken by a sandstorm in which al-Masīhī died.¹¹ The *Chahār Maqāla* extols the virtues of al-Masīhī and calls him the successor in philosophy to Aristotle. His book, *Kitāb al-Miʿa*, is recommended as part of the syllabus for medical students.¹²

Ibn Abī Usaybiʿa provides a list of al-Masīhī's books. He begins with *K. al-Miʿa fiʾl-tibb*, considered to be the best and most famous of his books. There are three other titles of books on medicine, three on philosophy, and one book, *Fiʾl-Wabāʾ* which he dedicated to the ruler of Khwarizm, Maʾmūn

7. Al-Qifī, *Taʾrīkh al-ḥukamāʾ*, ed. J. Lippert, (Leipzig, 1903), pp. 408-9.

8. IAU, I, 327-8.

9. Al-Qifī, *op. cit.*, p. 414.

10. *Ibid.*, p. 408.

11. Nizāmī-i ʿArūḍī, *Chahār Maqāla*, ed. and transl. by E. G. Browne, (Cambridge University Press, 1921), pp. 86-9.

12. *Ibid.*, p. 79.

included sections on medical theory, that is: the nature of humours, temperaments, crisis, coction, and so on. Diseases were described in a stereotyped way: cause, symptoms and signs, and therapy. The therapy section was usually the biggest part and often included a number of prescriptions. They also included a section on external or skin diseases, and a section on fevers. Many of them, but not all, also added a usually brief chapter on fractures and dislocations. Many of them also had a section on simple and compound drugs, and on poisons of animal origin or otherwise, and many books included a section on the preservation of health.

Kunnāshāt were used for practical purposes as manuals for medical practitioners and also for the teaching of practitioners and medical students.⁴ The relative emphasis on these two functions varied from one *kunnāsh* to another. For example, some *kunnāshāt* were no more than pure manuals of medicine, written in a simple, condensed style with a great deal of detail on therapeutics and very little on medical theory;⁵ this type was obviously of use to the practitioner. At the other end of the spectrum, was the type of *kunnāsh* which laid specific emphasis on medical theory, perhaps at the expense of detail on practical procedures, and which favoured a more complicated, intellectual approach; such *kunnāshāt* were useful for teaching purposes and could also be read by the intelligent and educated layman. Abū Sahl al-Masīhī's *kunnāsh* entitled *Kitāb al-mi'a fi'l-ṭibb* ("The Book of the Hundred on Medicine") is an example of the latter sort.

The study which follows is based entirely on manuscript material, for this worthy and elegant book has never been edited in whole or in part. The 13th-century writer, Nu'mān b. 'Alī al-Riḍā al-Isrā'īlī, composed a synopsis of it which was edited by Sharafī in 1959.⁶ Despite its prestige and popularity (see below), it was never translated either into Latin or into a modern language. Neither, for that matter, were any other of al-Masīhī's books.

Abū Sahl al-Masīhī's Biography

Abū Sahl 'Isā b. Yahya al-Masīhī al-Jurjānī was, as is revealed by his name, a Christian and a man of Jurjān in Persia. Al-Qiftī says that he was learned in the sciences of the ancients, and famous among his countrymen.

4. This is made clear in the introductions of many of these books, wherein it is stated that both practitioner and student will benefit from the book: a typical example is Ibn al-Jazār's introduction to his book, *Zaid al-musāfir wa qām al-hōfir*.

5. Such a book is Ibn Butlān's *Kunnāsh al-ruḥbān wa'l-adyā*, which is a simple manual of diseases and their treatments.

6. Qadri Sharafī, *Al-Ḥawāshī al-nu'māniyya wa'l-maḡāzid al-fubbiyya*, (Hyderabad, 1959). (I have not seen this work). There is a manuscript of the synopsis at the Bibliothèque Nationale, no. 2883. See M. G. de Slane, *Bibliothèque Nationale, Catalogue des Manuscrits Arabes* (Paris, 1883-95), p. 518.

A Mediaeval Compendium of Arabic Medicine:

Abū Sahl al-Masīhī's "Book of the Hundred"*

GHADA KARMI**

Introduction

The *kunnāsh*¹ (or compendium) type of book was very popular among Arabic physicians of the mediaeval period and became the commonest form of medical book to be written. It was supposed to be a comprehensive system of medicine in condensed form, so as to acquaint the reader with all the essentials of medicine without overloading him with too much detail. Many *kunnāshāt* declared this to be their explicit aim in their introductory remarks.² As time went on, the *kunnāsh* became the preferred type of medical work, to the despair of such educational purists as Ibn Ridwān who strongly deprecated the substitution of these derivative works for the original works of the ancients.³

These books were not identical either in arrangement or in content, but they resembled each other in certain important respects: they all included at some point a section on diseases arranged from head to toe; many also

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1 The word *kunnāsh* is interesting. It does not appear to be of Arabic derivation, but comes from the Syriac *kunnāsha* (M. Ullmann, *Wörterbuch der klassischen arabischen Sprache*, Vol. I (Wiesbaden, 1970), p. 387, 20 A.

2 For example, 'Alī b. al-'Abbās al-Mayūsī (fl. 949-982) writes in the introduction to his *kunnāsh*, *Kāmil al-sind'a al-tibbiyya* (Cairo, Bulaq, 1294/1877), Vol. I, p. 7, l 28f, that he has composed his book.

"That it might be easy (for physicians) to find one book which contains all that is necessary (in medicine). I will not leave out anything that might be needed by students and learned scholars."

3 Ibn Ridwān was an 11th-century physician of Cairo (d 1061) who took a great interest in the medical education of his day. For his biography, see Ibn Abi Usaybi'a, *'Uyūn al-anbā' fi tabaqāt al-afibbā'*, (henceforth IAU) ed. A. Müller, (Königsberg, 1884). He wrote a tract on this subject, *al-Nāfi' fi kayfiyyat ta'lim yunā'as al-ṭibb* ("the useful book on the quality of medical education"). The relevant extract is quoted by A. Z. Iskandar in his, "An attempted reconstruction of the late Alexandrian medical curriculum", *Med. Hist.*, 20 (1976), 241.

One wonders whether the *kunnāsh* type of book was not always preferred, almost from the beginning of the translation movement from Greek and Syriac into Arabic. *Kunnāshāt* in Syriac were certainly available before 700 A. D. and came to be written in Arabic from 800 A. D. onwards.

et se l'approprie. Déchaînement d'al-Sijzī qui l'attaque alors avec la dernière véhémence, sans toutefois le nommer. Entre temps al-Qūhī et al-Saghānī étaient entrés en lice et donnaient leurs solutions en 360 H., semble-t-il, celle d'al-Qūhī étant la plus élégante de toutes et antérieure de peu à celle d'al-Saghānī.

La construction de l'heptagone régulier restera une des grandes questions classiques: al-Qūhī en fera l'objet de son deuxième mémoire, Ibn al-Layth en donnera une 2^e solution (dans sa 3^e lettre). Celui-ci est devenu depuis un géomètre réputé dont al-Bīrūnī et 'Omar al-Khayyām feront l'éloge.⁹ Ibn al-Haytham donne une solution entre 417 H. et 429 H.¹⁰ Al-Bīrūnī évoque l'heptagone dans "al-Qānūn al-Mas'ūdi, al-Samaw'al b. Yahyā dans *Kashf 'uwār al-munajjimīn*.¹¹ L'heptagone donne l'élan vers d'autres tentatives; construction de l'ennéagone régulier,¹² construction du polygone régulier de 11 côtés (qu'Ibn al-Layth crut avoir trouvée), du polygone régulier de 13 côtés, division de l'angle en 5 parties égales.¹³ Il reste un des multiples témoins de la faveur que la géométrie a connue dans la 2^e moitié du 4^e siècle, époque où l'on peut voir la première gestation de l'algèbre géométrique d'Omār al-Khayyām.

9. Al-Bīrūnī, *Al-Qānūn al-Mas'ūdi*, (Hyderabad, 1954), vol. 1, p. 297 Al-Khayyām, *Al-jabr w'al-muqābala* Ms. Columbia Univ. Or. Smith 45, 10, pp. 28, 37.

10. Ibn Abi 'Uṣaybi'a, *'Uyūn al-anbā'*, (Cairo, 1882), vol. 2, p. 98.

11. Al-Bīrūnī, *ibid* p. 297 Al-Samaw'al b. Yahyā, *Kashf 'uwār al-munajjimīn*, Ms. Leiden Or. 98, f. 2b.

12. *Al-Qānūn al-Mas'ūdi*, vol. 1, p. 287; voir aussi *al-Rasād'il al-musafarrīqa fī-l-hay'a* (Hyderabad, 1949), 10, p. 22.

13. Al-Samaw'al b. Yahyā, *op. cit.* f. 21

4. Construction du triangle ABD tel que $\widehat{B} = 2\widehat{A}$ et $\widehat{A} = 2\widehat{D}$ et par suite division du cercle en sept parties égales.

Méthode d'al-Qūhī (1er mémoire)

La division d'un segment AB arbitraire en C et D de sorte que $CB \cdot CD = AC^2$, $AD \cdot AC = DB^2$ a donc été opérée. Al-Qūhī a démontré aussi que chacun des segments BD , DC , AC est inférieure à la somme des deux autres. Il peut donc construire le triangle CDE où $DE = DB$ et $CE = AC$.

Je dis que $\widehat{ECD} = 2\widehat{EDC} = 4\widehat{CED}$. (Par suite si on circonscrit un cercle au triangle CDE on aura la division du cercle en sept parties égales). Prolongeons EC en CF tel que $CF = CD$. On a $BC \cdot CD = AC^2 = CE^2$ d'où $BC/CE = CE/CD$. Les triangles BCE et DCE sont semblables. D'où $\widehat{B} = \widehat{DEC}$ et $\widehat{CEB} = \widehat{EDC}$. Mais \widehat{EDC} extérieur au triangle BDE égale $2\widehat{B}$, donc $\widehat{EDC} = 2\widehat{CED}$. De même $\widehat{ECD} = 2\widehat{CDF} = 2\widehat{CFD}$. Comme $CE = AC$ et $FC = AD$ alors $AD \cdot AC = FE \cdot EC = DB^2 = DF^2$.

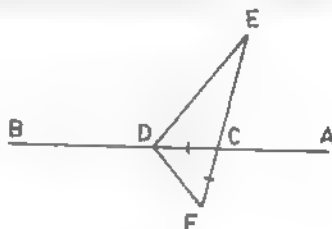


Fig 6

D'où $\frac{FE}{DE} = \frac{DE}{EC}$. Les triangles EFD et CED sont semblables d'où $\widehat{EDC} = \widehat{EFD}$.

Par suite $\widehat{ECD} = 2\widehat{EDC}$.

IV

L'historique de la découverte peut être présenté ainsi:

En 358 H., ou peu avant, Ibn al-Layth encore inconnu et qui brûle de percer, donne le premier coup de pioche dans la construction de l'heptagone. Il énonce quatre lemmes, ramène la question à la division d'un segment suivant une certaine relation, et réussit cette division, pense-t-il, par l'intersection de cercles et de droites. Or il est en correspondance avec le jeune mathématicien al-Sijzī. Celui-ci découvre la faute, s'efforce en vain de la corriger et finit par recourir à Abū Sa'īd al-'Alā' ibn Sahl. Ce géomètre y parvient par les sections coniques. Mis au courant, Ibn al-Layth malheureux, de voir l'occasion lui échapper, apporte à la solution quelques modifications insignifiantes

3. Partage du segment AB par les sections coniques, al-Qūhī (1er mémoire)

Prenons deux droites perpendiculaires en D et $DA = DS$ (longueur arbitraire). Traçons la parabole d'axe SD , de sommet S et passant par A . Traçons l'hyperbole équilatère de sommets D et A et d'axe AD . Elle coupe la parabole en M dont la projection est E sur AD , et L sur SD . Prenons AB DL sur le prolongement de DA .

Dans la parabole $\overline{ML}^2 = SD \cdot SL$ ou $\overline{ED}^2 = DA \cdot DB$

Dans l'hyperbole $\overline{ME}^2 = DE \cdot AE$ ou $\overline{AB}^2 = DE \cdot EA$

Ainsi un segment BE a été divisé dans les conditions voulues.

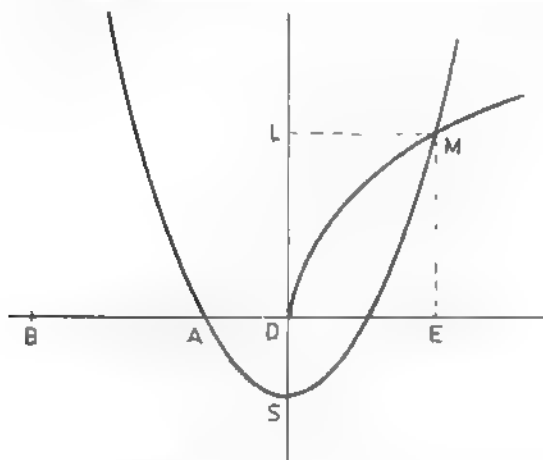


Fig. 4

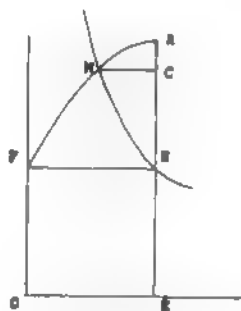


Fig. 5

Méthode d'al-Sijzi et d'Ibn al-Layth

Sur le prolongement du côté EB du carré $OEBF$ on prend $BA = EB$. On trace la parabole d'axe AB , de sommet A passant par F . (Donc dans l'équation de la parabole $y^2 = 2px$, $2p = AB$). On trace aussi l'hyperbole d'asymptotes OE , OF passant par B . Elle coupe la parabole en M qui se projette en C sur AB . Posons $BE = BF - BA = a$, M appartenant à l'hyperbole $(a + BC)(a - MC) = a^2$ d'où $aBC = (a + BC)MC$.

Comme M appartient à la parabole $MC = \sqrt{AC \cdot AB}$. Par suite AB est divisé en C suivant la condition voulue.

III

Contenu mathématique des mémoires

Pour construire l'heptagone régulier il s'agit de diviser un cercle en 7 parties égales.

1. (1) Archimède suivi par al-Qūhī (premier mémoire) et al-Şaghānī se propose de construire le triangle ABD où $\widehat{B} = 2\widehat{A}$ et $\widehat{A} = 2\widehat{D}$.

(2) Al-Qūhī (2^e mémoire) veut construire le triangle ABG où $\widehat{A} = 5\widehat{B} = 5\widehat{G}$.

(3) Ibn al-Layth et al-Sijzī construisent ADE où $\widehat{D} = \widehat{E} = 3\widehat{A}$.

2. Dans une 2^e étape, les égalités entre les angles vont céder la place à des égalités entre les côtés.

Archimède et al-Qūhī (1^{re} et 2^e mémoires) et al-Şaghānī aboutissent à division d'un segment en trois parties (voir début de l'article). Donnons la méthode d'al-Qūhī (2^e mémoire).

Dans le triangle ABC , $\widehat{A} = 5\widehat{B} = 5\widehat{C}$, nous prolongeons BA en ADE de sorte que $\widehat{ACD} = \widehat{ACB}$ et $DC = DE$. Les triangles semblables EDC et ECA , ADC et DBC donnent:

$$ED \cdot EA = \overline{EC}^2 = \overline{AC}^2 = \overline{AB}^2$$

$$DA \cdot DB = \overline{CD}^2 = \overline{DE}^2$$

Ibn al-Layth (dans mémoire perdu) et al-Sijzī remplacent la relation angulaire (3) par la division de AB en deux segments AC et BC tels que

$$\frac{\sqrt{AB \cdot AC}}{BC} = \frac{AB}{AB + BC}.$$

Ibn al-Layth indique dans sa 2^e lettre une autre division de AB en C et D .

telle que

$$AB \cdot DB = \overline{AC}^2$$

$$CB \cdot CD = \overline{AC}^2$$

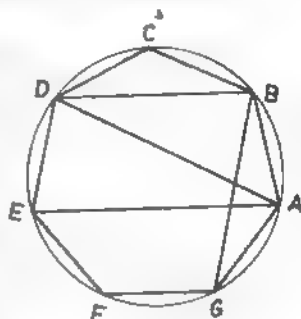


Fig. 1

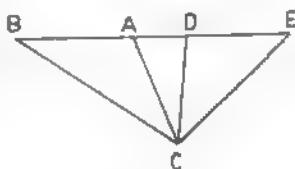


Fig. 2



Fig. 3

la course fiévreuse vers le but, les chutes, les arrêts forcés, voire les irrégularités ne vont pas manquer: toutes circonstances qui donneront lieu à une querelle de priorité sur laquelle se greffe pour l'exacerber la vieille "Querelle des Anciens et des Modernes". Dans le brouhaha des revendications contradictoires et des anathèmes qui vont s'élever, nous avons pour interprète et guide précieux sinon impartial, un géomètre attardé al-Shannī⁸ qui s'est intéressé à la querelle et en connaît bien les dessous.

II

Les mémoires à verser au dossier du procès sont:

1^o) Une première lettre d'Abū'l-Jūd ibn al-Layth, adressée en 358 H. à Abū'l-Ḥusayn 'Ubayd Allāh b. Ahmad, dont copie adressée à Abū M. 'Abdallāh b. 'Alī al-Ḥāsib. Cette lettre est perdue mais son contenu nous est révélé par les lettres 2 et 3 d'Ibn al-Layth, 4 d'al-Sijzī, 8 d'al-Shannī.

2^o) Lettre adressée par Ibn al-Layth à Abū M. 'Abdallāh b. 'Alī al-Ḥāsib. L'auteur y analyse les solutions d'al-Qūhī et d'al-Ṣaghānī et la sienne propre. (Ms Paris 4821, f. 37^b-46^a.)

3^o) Lettre d'Ibn al-Layth à Abū'l-Ḥasan Ahmad b. Ishāq, plusieurs années après la clôture de la querelle (Ms Caire 7805, f. 117^b - 120^a.)

4^o) Mémoire d'al-Sijzī sur la construction de l'heptagone régulier et la trisection de l'angle; (Ms Paris 4821, f. 10^b-16^b; le même que Caire 7805 f. 113 - 117.)

5^o) Mémoire d'al-Qūhī dédié à 'Adud al-Dawla. (Ms Paris 4821, 17^b - 23^b; Caire 7804 f. 222^b - 225^a. La dédicace au roi dans le ms. Caire est très embellie).

6^o) 2^e mémoire d'al-Qūhī dédié à Abū'l-Fawāris b. 'Adud al-Dawla postérieur au précédent et tout à fait différent. (Ms Paris 4821, f. 1^b - 8^a.)

7^o) Mémoire d'al-Ṣaghānī dédié à 'Adud al-Dawla. Il y est fait mention d'un mémoire antérieur présenté au roi à Rayy et dont le mémoire actuel est un remaniement. La date de résolution d'une proposition du mémoire est fixée au 12.X.360 H. (Ms Paris 4821, 23^b - 28^b.)

8^o) Mémoire d'al-Shannī, *Kitāb kashf tamvīh Abū'l-Jūd* (Ms Caire 780, f. 129^b-134^b). Al-Shannī relate les circonstances de la découverte de la solution, les erreurs d'Abū'l-Jūd et analyse les solutions.

De ces mémoires, C. Schoy a étudié en 1926, la construction de l'heptagone par al-Sijzī (*Isis*, 8 (1926), 21-35), et Y. Samplonius, en 1963, celle d'al-Qūhī (*Janus* 50 (1963), 227-249. d'après F. Sezgin, *CAS* V, p. 318, 3^o).

⁸ *Ibid.*, p. 352.

This is a French version of a paper which appeared in Arabic in JHAS, 1 (1977), 352-384. Its present form makes the results available to a wider circle of readers.

Construction de l'heptagone régulier par les Arabes au 4^e siècle de l'hégire

ADEL ANBOURA *

I

Au 3^e siècle H., Thābit b. Qurra traduit un mémoire d'Archimède sur l'heptagone régulier dont le texte grec est actuellement perdu.¹ La solution d'Archimède revient à diviser un segment AB en deux points C et D de sorte que

$$\begin{aligned} (AC + CD) \cdot CD &= DB^2 \\ (CD + DB) \cdot DB &= AC^2 \end{aligned}$$


ce qu'Archimède résout par le procédé de "la règle mobile" et non par la géométrie fixe.² On sait que la construction de l'heptagone régulier mène à une équation du 3^e degré et par conséquent, ne peut résoudre par intersection de cercles et de droites.

La question en reste là jusque vers le milieu du 4^e siècle H. A cette époque un intense bouillonnement agite la vie scientifique arabe, exalté par la dynastie Bouyide. Quatre géomètres de valeur vont s'attaquer à la construction de l'heptagone. Ce sont:

1. Abū'l-Jūd M. b. al-Layth³
2. Abū Sa'īd Aḥmad b. M. 'Abd al-Jalīl al-Sijzī⁴
3. Abū Sahl Wayjan b. Rustam al-Qūhī⁵
4. Abū Ḥamid Aḥmad b. M. b. al-Ḥusayn al-Ṣaghānī⁶

En coulisse se tient un géomètre éminent dont l'intervention auprès d'Ibn al-Layth et d'al-Sijzī sera décisive: Abū Sa'īd al-'Alā' b. Sahl.⁷ Dans

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1. T. L. Heath, *A Manual of Greek Mathematics*, (Oxford, 1931), pp. 283-286.

2. *Ibid.* pp. 340-342.

3. F. Sezgin, *Geschichte des arabischen Schrifttums*, Bd. V (Leiden, E. V. Brill, 1974), pp. 353-355 (où l'on trouvera toutes références utiles).

4. *Ibid.* pp. 329-334.

5. *Ibid.* pp. 314-321, 403.

6. *Ibid.* p. 311.

7. *Ibid.* pp. 341-342.

The intersection of any circular cone or cylinder with a plane parallel to the base is also a circle. And the line drawn from the vertex to the center of the base passes through the center of the intersection.

The proposition is followed by an example with proof, but no drawing.

References

Yvonne Dold-Samplonius, *Book of Assumptions by Aqāṭun* (Doctoral Thesis, Amsterdam, 1977).

Max Krause, "Stambuler Handschriften islamischer Mathematiker", *Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik* Abt. B, vol. 3 (Berlin, 1934), 437-532.

Carlo A. Nallino, "Tracce di opere greche giunte agli Arabi per tramite persiani", *A Volume of Oriental Studies Presented to Edward G. Browne*, T. W. Arnald and R. A. Nicholson eds. (Cambridge, 1922), 345-363.

Ibn al-Qūfī, *Ta'rikh al-hukamā'*, Julius Lippert ed. (Leipzig, 1903).

Fuat Sezgin, *Geschichte des arabischen Schrifttums*. Band V, Mathematik. Bis ca. 430 H (Leiden, 1974).

Manfred Ullmann, "Der Werwolf", *Wiener Zeitschrift für die Kunde des Morgenlandes*, 68 (1976), 171-184.

with an article in the last two marginal notes (fol. 102v). Aflāṭūn is never written with an article. Van Ess adds that in general an article with the name of an ancient author is somewhat curious. As the addition "translated from the Greek language" has been omitted in the Istanbul manuscript, its redactor may not have recognized Aqāṭun as an ancient Greek author. As the name Aqāṭun occurs, according to Lippert in this same form in all codices of the *Ta'rikh al-hukamā'* (p 195), I assume its writing to be correct. This would point to a Greek name like Ἐκάτων. A more probable Greek name would be Ἀγαθών. However, this means three exceptions in one word from the normal rules of transliteration. M. Ullmann has shown that the Greek word *λυκανθρωπος* (werewolf) became *quṭrub* in Arabic by means of a Syrian intermediary, in which θ was already rendered by f. In our case he also suggested an intermediary, namely Pahlavi (= the Iranian language of Sassanid Persia). D. N. MacKenzie and W. Sundermann agreed with this eventual possibility, and gave more details:

Although one expects *g* in Pahlavi for *γ*, *k* sometimes occurs (*hykmen* for *γγεμόν*). Then Ἀγαθών could have been rendered by **k'twn*, which would have to be written in Arabic as **q'tun*. Because of the ambiguity of some Pahlavi letters, the ending *wn* could have been misread as *-n*. In this way one could arrive at **q'tn*, Aqāṭun. Already C. A. Nallino pointed out that scientific works were translated from Greek into Pahlavi into Arabic. He notes in this context that the extreme ambiguity of Pahlavi writing makes it impossible to read foreign names with certainty. A. Schall comments that the rules in everyday life are not so strict: the correlation *γ* ~ ق (*q*) still exists in dialects, especially in names, e.g. (Jordan:) كُتوس (priest) is rendered by Goussous, and (Sudan:) عبد القادر by Abdel Gadir. Ἀγαθών was a rather common Greek name, but no mention of a mathematician of this name has been transmitted to us.

Appendix

Among the pages of the treatise one, fol. 95, does not belong to the text, which after fol. 94v continues on fol. 96r. This page may belong to another treatise of the manuscript, as it contains on one side, fol. 95v, a referential proposition which has no apparent connection with the contents of the *Kitāb al-mafrūdāt*. It is written in the same hand as our treatise. Fol. 95r consists of two three-dimensional drawings not belonging to the proposition on fol. 95v. Seemingly they are not of an astronomical nature.

The proposition on fol. 95v reads: Proposition by Muḥammad ibn Mūsā from the book "On the Sphere", which refers to it:

His name is given as Muḥammad ibn Sartāq from Marāgha. It is remarked that he has studied this book by Aqāṭun, has verified and corrected it. The redactor is not otherwise known to us.

To the title of the Bankipore manuscript is added "Thābit ibn Qurra translated the treatise from the Greek language into the Arabic language". This leads to the question of what the original Greek title may have been, and the Greek spelling of Aqāṭun [On author and title see thesis, Chapter II]. The suppositions were excluded from the thesis, as no definitive answer can be given. The hypotheses are laid down in the following.

a. The Title

In the Arabic sources we find the titles *Kitāb al-ma'khūdhāt*, *Kitāb al-mu'ayyāt*, *Kitāb al-mafrūdāt*. The first of these is connected with the verb *akhadha* (أخذ) with basic meaning "to take". This corresponds with the Greek verb λαβειν. Also the original meaning of *ma'khūdhāt*, i. e. takings, receipts, returns (commerce) and of λημματα are equivalent. Thus *Kitāb al-ma'khūdhāt*, refers to the Greek title "Lemmata", e. g. Archimedes.

The second title, *Kitāb al-mu'ayyāt* is related to the verb *a'aya* (عاض IV) which means "to present, offer". The corresponding Greek verb is δισκομαι. Thus *Kitāb al-mu'ayyāt* is the translation of the Greek title δισκουμα, e. g. Euclid's Data.

As for the title *Kitāb al-mafrūdāt*: in the case of Thābit ibn Qurra this title is sometimes translated as "Data". As I pointed out above, Data has usually a different Arabic equivalent. Therefore I tried to find another possible Greek title. *Mafrūdāt* is a form of the verb *farada* (فرس) meaning something like "to decide, impose, assume, suppose, postulate". This could be rendered by the Greek verb υποτιθεσθαι (inf. med.), and thus *mafrūdāt* could be a translation of υποθεσεις. To this F. M. Bruns objects that nowadays the Arabic word for assumption, supposition, hypothesis is *isfīrād*. He therefore suggests starting from a more special meaning of *farada*, namely "to take for granted". This could then correspond with the Greek verb συγχωρεω and we could assume *mafrūdāt* to be a translation of συγχωρησεις.

This small exposition may have made clear how difficult it is, if not impossible, to establish the original Greek title.

b. The Author

The author's Greek name, which was arabized into Aqāṭun can only be guessed at. Some want to explain Aqāṭun as a misreading of Aflāṭūn (= Plato). According to J. van Ess this cannot be correct as Aqāṭun is written

Prop. 40 (= Prop. 43): If in the right-angled triangle ABG with angle ABG right, angle BAG is bisected by line AD, line AE drawn at random, from point E line EZ constructed parallel to line AD, ZB joined cutting AD in T, and ET joined, then $AZ : ZT = AE : ET$.

Prop. 41 (1) Let in the right-angled triangle ABG, with angle BAG right, from point A to line BG the lines AD and AE be drawn such that angle DAG is equal to angle GAE, then $BE : EG = BD : DG$.

(2) Conversely: If $BE : EG = BD : DG$ [and angle BAG be right], then $\angle DAG = \angle GAE$.

(3): (margin) Let $\angle EAG = \angle CAD$, and $BD : DG = BE : EG$, then $\angle GAB = 90^\circ$.

Prop. 42 Let in triangle ABG angle B be bisected by line BD and angle G by line GD, then angle A is bisected by line AD.

Prop. 43 is identical with Prop. 40 but has been proved in a different way. Here Propositions 41 and 42 are used, whereas for the proof of Prop. 40 Propositions 38 and 39 are applied.

From these contents the impression is gained that Aqāṭun made an effort to understand plane geometry. Maybe this was done in a school where this treatise served as a textbook or exercise book. In this case, however, one would suppose more copies of the treatise to be extant. It seems therefore more probable to me that this was a one-man effort. Aqāṭun worked out new propositions and also, like Pappus, gave some proofs that had been left out in the existing mathematical literature, but no references are added. There may have been a mutual influence between Pappus and Aqāṭun. Other mathematicians exercising an influence on our author appear to be Archimedes, Euclid, and Apollonius. Also a connection with Menelaus exists: propositions 33 and 34 contain two special cases of Menelaus' theorem in the plane. Some of the propositions in the *Kitāb al-mafrūdat* may be later Arabic insertions [Thesis, Chapter I].

As the treatise is only moderately original, which may be the reason why not many copies seem to have existed, its impact on later mathematics was small. The only connection found is in Ibn al-Haytham. An interesting feature of our copy are the marginal notes. In these notes improvements on the text are made, i. e. some missing words are inserted and some different proofs added. This is done conscientiously and with great care. E.g. in the case of Prop. 6 the addition ends "I had written down this remark before looking at the construction of the proof. So I apologize." The marginal notes at the beginning and the end of the treatise inform us about the redactor.

Prop. 31: If the tangents ED and EA to circle ABTD be drawn, and if an arbitrary line EZ be drawn cutting the circle at Z and B; if AD be joined, if to EZ the perpendicular ZT be drawn cutting AD in Y and the circle in T, and if EY and ZD be joined, then $\angle DEY = 2 \angle DZT$.

Prop. 32: If to the semicircle with diameter AG the tangents EA and EB be drawn, EB and AG be extended until the intersection point D, if BZ be drawn parallel to AD, DZ and AB be joined intersecting in H, and HT be drawn perpendicular to AG, then T is the center of the circle.

Prop. 33: If line AG of triangle ABG be bisected at D, line BA be extended to E, and ED be joined and extended to Z on line BG, then $BE : EA = BZ : ZG$.

Conversely, if $BE : EA = BZ : ZG$, then $AD = DG$.

Prop. 34: If line BA of triangle ABG be extended from A to E, line BG bisected at Z, and line AG divided at D such that $BE : EA = GD : DA$, then E, D, Z are collinear.

Prop. 35: Through point D outside line AB let the lines ED and DZ be drawn both parallel to line AB, then EDZ is a straight line.

Prop. 36: From point E let the lines EZ and ED be drawn cutting the lines AB, AG, AD respectively in Z, T, L and in B, G, D, and let $EZ : ZT = EL : LT$, then $EB : BG = ED : DG$.

Prop. 37: In the right-angled triangle ABC, with angle BAG right, let the lines AD and AE be drawn such that angle DAE is equal to angle ABC, and from point B let the perpendicular BZ to AE [cutting AD in T] be drawn and extended to H on AG. Then $DA \cdot AT + GB \cdot BD = HB \cdot BT + CA \cdot AH$; and secondly $GB \cdot BD + CA \cdot AH = AB^2 \cdot DA \cdot AT + GB \cdot BD - HB \cdot BT + CA \cdot AH$.

Prop. 38 (1): Let the lines AB, AG, AD be of equal length and DG, GB, BD be joined, then $\angle GBA + \angle GDB = 90^\circ$.

(2): Moreover, if $AB = AG$ and $\angle GBA + \angle GDB = 90^\circ$, then the lines AB, AG, AD are of equal length.

(3): Also, if $AD = AB$ and $\angle GBA + \angle GDB = 90^\circ$, then the lines AD, AG, AB are of equal length.

(4): Finally, if $AD = AG$ and $\angle GBA + \angle GDB = 90^\circ$, then the lines AD, AG, AB are of equal length.

Prop. 39: If in triangle ABC line AD is drawn meeting BG in D such that angle DAG is equal to angle ABG, then

$$BG : GD = BG^2 : GA^2 = BA^2 : AD^2.$$

Prop. 20: If in the isosceles triangle ABG , with AB equal to AG , lines AE and AD be drawn, meeting BG at E and D such that $BD \cdot DG : DA^2 = GE \cdot EB : EA^2$, then $DA = AE$.

Prop. 21: Let in triangle ABG angle BAG be bisected by line AD , meeting BG at D , then $(BA + AG) : GB = AB : BD$.

Prop. 22: Let from triangle ABG AB be extended to D and AG to E , let DH be drawn parallel to EB and EZ parallel to DG , then ZH will be parallel to BG .

Prop. 23: Let in triangle ABG AD be equal to BE and AZ equal to GH , let GE , GD , BZ , BH be joined, GE and BZ intersecting in W and GD and BH in S . If AS and AW be joined and extended meeting BG in T and Y , then BT is equal to GY .

Prop. 24: Let angle AGB in the right-angled triangle ABG , with angle ABG right, be bisected by line GD , and angle DAE be equal either to angle AGD or angle BGD , then $GD > GE$.

Prop. 25: Let angle AGB in the right-angled triangle ABG , with angle ABG right, be divided by line GD such that angle BGD is twice angle DGA , then $BG \cdot GA > GD^2$.

Prop. 26: Let in the semicircle with diameter AD arc AB be equal to arc BC , let GD be joined, and BE be drawn perpendicular to AD , then $GD < ED$.

Prop. 27: If in triangle ABG BG be bisected at D and AD be joined. If from B an arbitrary line be drawn cutting AD in Z and AG in E , and GZ be joined and extended to H on AB , then, if HE be joined, it is parallel to BG .

Prop. 28: If in the circle-segment standing on line BC arc BC be bisected at A , E be taken on the extension of BC , and AG and AE cutting the segment at D be joined, then $EA \cdot AD = AG^2$.

Prop. 29: If through two circles intersecting in A and D , an arbitrary line be drawn cutting one circle in Z and H and the other in B and E , and ZA , AB , ED , DH be joined, then $\angle ZAB = \angle EDH$.

Secondly, if HD and ZA be extended to K and T on circle $ABED$, and BK and ET be joined intersecting in L , then $BL = LE$.

Prop. 30: If from triangle ABG with angle BAG right, BA be extended to D , and from D , DE be drawn perpendicular to BG cutting AG in Z , then $BD \cdot DA = GZ \cdot ZA + ZD^2$.

Conversely: If $BD \cdot DA = GZ \cdot ZA + ZD^2$, then $\angle DEB = 90^\circ$

Prop. 6: If BG is the diameter of a semicircle, and the chords AG, BD meet in Z, and if BA, GD be drawn meeting in E, then $BD \cdot DZ = GD \cdot DE$.

Prop. 7: Let BG be the diameter of a semicircle, and the chords AG, BD meet in Y. Take Z on BD and E on AG so that $BD \cdot DY = DZ^2$ and $GA \cdot AY = AE^2$, and let EB, ZG be joined meeting in H, then $ZH = HE$.

Prop. 8: In the equilateral triangle ABG the heights AZ, BD, GE are of equal length.

Prop. 9: Let ABG be an equilateral triangle, and AD its height. Let from a point E on BD the perpendiculars EZ and EH be drawn to the sides GA and AB, then $AD = EZ + EH$.

Prop. 10: Let ABG be an equilateral triangle, and AD its height. Let from an interior point E the perpendiculars to the sides EZ, EH, ET be drawn, then $AD = EZ + EH + ET$.

Prop. 11: If in triangle ABG the line AD be drawn meeting BG at D such that angle BAD be equal to angle AGD, then $GB \cdot BD = AB^2$.

Prop. 12: Let in triangle ABC, with AB equal to AC, AD be drawn perpendicular to AB meeting the extension of BC in D. If AB be bisected at E and ED be joined cutting AC at Z, and if through Z, HZ be drawn parallel to AB, then $DA \cdot AH = AC^2$.

Prop. 13: If in triangle ABG, with AB equal to AG, AD be drawn perpendicular to BG, then $2 \cdot DG \cdot GB = AG^2$.

Prop. 14: If in triangle ABG the perpendicular AD to BG be drawn, then $BD^2 - DG^2 = BA^2 - AG^2$.

Prop. 15: Let line AB be equal to line AG and line BD equal to line DG, and let both angles BAG and BDG be right, then $\angle ABD = \angle AGD$.

Prop. 16: Let A be the right angle of the right-angled triangle ABG. If BG be bisected at D and AD be joined, then $BD = DG = DA$.

Prop. 17: Let in the right-angled triangle ABG, with angle BAG right, on the extension of AG a point D be taken, from which DE is drawn perpendicular to BG and cutting AB at Z. Let CZ be joined and on it H be taken such that $BH^2 = AB \cdot BZ$ and let DH be joined, then $DH^2 = DE \cdot ZD$.

Prop. 18: Let the lines AB and BG meet at B, and on AB point D be taken, such that $AB^2 = AD^2 + BG^2$. Let DG be joined and bisected at E, and AE be joined, then $\angle DAE = \angle DGB$.

Prop. 19: If in the isosceles triangle ABG, with AB equal to AG, an arbitrary line AD be drawn cutting BG at D, then $BD \cdot DG + DA^2 = AG^2$.

manuscript 2468,29 (fol. 141r - 144v) [Sezgin, p. 135]. An Arabic edition of the latter together with Bankipore 2468,28 (fol. 134v - 141r, *Kitāb Arshumidis fīl-dawā'ir al-mutamassa*, has been published by the Osmania Oriental Publications Bureau (Hyderabad-Du., 1947).

In the Aya Sofia manuscript the date of copying is given as ca. A. D. 1230, mentioning as place of copying, sometimes Damascus, sometimes Marāgha. At the end of the Bankipore manuscript the date of its composition is indicated as A. D. 1027/1028. In the present copy some of the treatises are dated Mosul A. D. 1234/35. Thus the present copies of both treatises date from the same period. Both are written in Naskhī. The mathematical quality of the treatise is higher in the Aya Sofia manuscript than in the Bankipore manuscript.

The reasons for accepting the title *Kitāb al-mafrūdāt* and Aqāṭun as its author are laid down in Chapter II of the thesis.

The Contents [Thesis, Chapter III]

Prop. 1: If the base BG of the circle-segment ABG be extended in either direction with pieces of equal length, and from the endpoints D and E the tangents EZ and DH be drawn to the segment, then the line ZH connecting the tangential points is parallel to the line ED.

Prop. 2: Assume the two lines DB and DC are tangents to a circle. Let the chord BG connecting the tangential points be extended to E, and let from E a third tangent be drawn, touching at A and meeting DC in Z and BD in T, then $TE : EZ = TA : AZ$.

Prop. 3: Assume the two lines EG and ED are tangents to a circle, while EB cuts it at H and B. Let DA be the chord through D parallel to EB, and let AG meet BH in Z. Then $BZ = ZH$.

Remark: There is no drawing in the Aya Sofia manuscript as the room left open for this purpose is too little. Later I discovered that the drawing had been made on a loose leaflet which lies now, on the microfilm, between fol. 87v and fol. 88r.

Prop. 4: Let ABG be an isosceles triangle and AD the perpendicular to the base BG. Assume on AB the points Z, E such that $BD^2 = BE \cdot BZ$. Let ZD be joined, ZH be drawn parallel to BG, and EH be joined, then $\angle EHG = 2 \angle AZD$.

Prop. 5. If AG is the diameter of a semicircle and B the middle of the arc AG; let from D, on the extension of AG, DB be joined cutting the circle at Y. If $YE = EB$ and from the center Z, ZE be drawn until it meets the extension of AB in H, then $AH : HB = DZ : ZB$.

Some Remarks on the "Book of Assumptions by Aqātun"

YVONNE DOLD-SAMPLONIUS*

Introduction and Conclusion

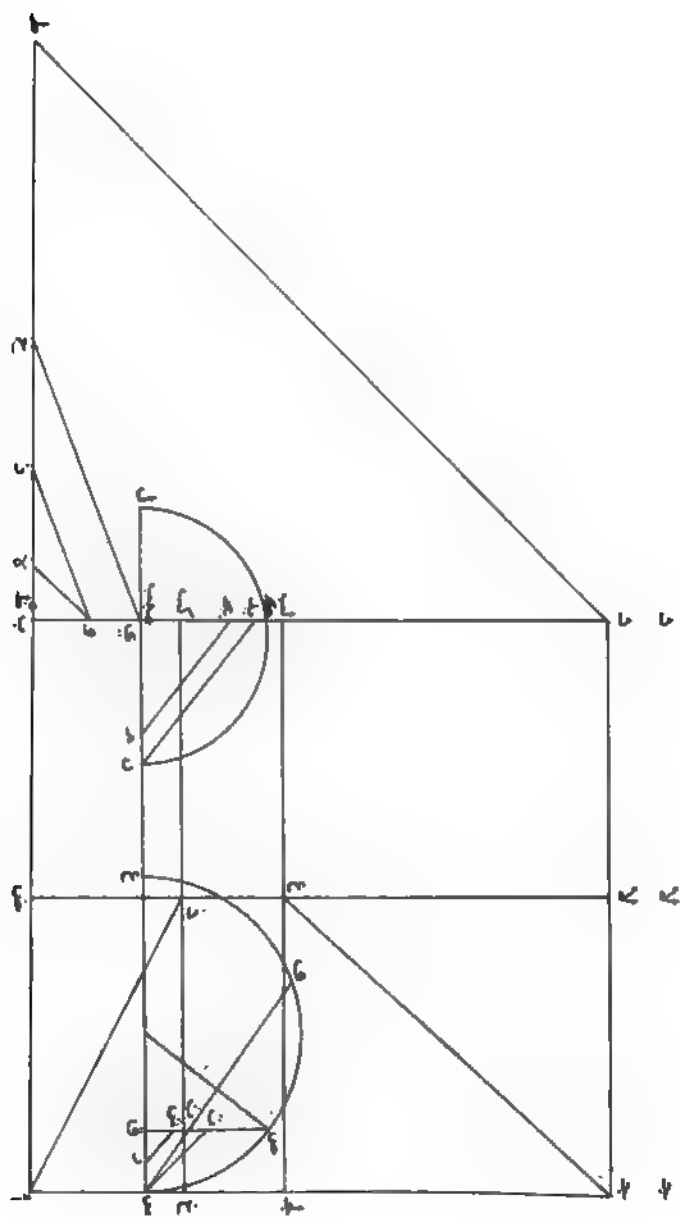
The treatise *Kitāb al-mafrūdāt li lqātun* (Book of Assumptions by Aqātun) has been treated in full in my doctoral thesis (Amsterdam, 1977). The present paper contains an abstract of this thesis. It consists of the contents of the treatise, i.e. propositions only without either proofs or drawings, along with some remarks describing the manuscript and pointing out several influences. In addition the questions of the original Greek title and putative Greek name of the author are extensively discussed. The offered solution is, however, too vague to have been included in the thesis.

My conclusion is that the treatise contains interesting propositions, but no sensational theorems. Some propositions deal with fundamental properties of triangles, some go in the direction of trigonometry, others could be connected with optics. The author, i.e. Aqātun seems to have been a man with a good knowledge of the mathematical literature, judging from the different influences on his treatise (Thesis, Chapter IV). He may have lived around the same time as Pappus: on the one hand Aqātun gives two converses to a lemma by Pappus (prop. 41), on the other hand both Pappus and Aqātun prove a lemma related to Apollonius' *Conics* (prop. 27) and a lemma connected with Euclid's *Porisms* (prop. 22); these proofs by Aqātun and Pappus are similar but not identical. The treatise was still of value and interest to Arabic mathematicians in the thirteenth century, according to the extensive marginal notes. Yet the sphere of influence apparently was not very large.

Description of the Manuscript [Thesis, Chapter I]

The treatise "Book of Assumptions by Aqātun", *Kitāb al-mafrūdāt li Aqātun*, is contained in the Istanbul manuscript Aya Sofia 4830,5 (fol. 89v-102v) [Krause, p. 439]. It consists of 43 propositions dealing with plane geometry. Nineteen propositions, all from the first half, form a separate treatise entitled "Book by Archimedes on the Elements of Geometry", *Kitāb Arshimidis fi'l-uṣūl al-handasiya*. This is contained in the Bankipore

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هذا الشكل وبصفحة عن السهو القليل إن وقع (١٨) في بعض حساناتها الخزية فقط . وإن عثر على خطأ في بعض براهينه فيها (١٩) عليه مقبدا ادّعاءه (١١٠) فقد (١١١) عُمِيَ عليها لكثرة المقدمات واختلاط الهندسية فيها بالحساب ، ولا يكر كثرة التطويل في مقدماتها فإن الوصول ■ إلى المطلوب البرهاني بكثرة المقدمات < و > بالمتوسطة مع العصمة من العلق إن كانت يكون (١١٢) إليه بالسرية والارتياض . وأدل على < أن > الإصابة في المعقولات بكثر بالضرورة مقدمات براهينها ومتوسطاتها . وأعظم فوائد العلوم الرياضية إنما هو ذلك . ولقد (١١٣) تَحَيَّزَتْ عن التطويل في مقدمات براهين هذا الشكل مع كونها حقا ضرورية (١١٤) في إفادة النتيجة المطلوبة . ثم إن أشار المحذوم المعجم فسأعرض سائر الطرق (١١٥) ، على رأيه لما قد العالی إن شاء الله تعالى .

(١١٦) والسلام (١١٦) .

١١٨ - ك ، ل ، وقعت ١٠٩ - ك ص ١١٠ ل : ادعاء ك : دعاء ولقصود ما ذهب إليه
١١٩ - ك ، ل ، قد ١١٢ - ل ناقصة ١١٣ ك ، ل ولهذا ١١٤ - ك ، ل : سروديا
١١٥ - ك الطرف ١١٦ - ر : والحمد لله وحده

من أحد عشر جزءا ونصفه عشرة أجزاء من أحد عشر جزءا من الواحد وإدا (٨٨)
 قسما العشرة بأحد عشر قسما يكون كل قسم عشرة أجزاء من أحد عشر من الواحد
 فخط بـ ي جزآن من أحد عشر جزءا من بد العشرة وسطح بـ س (٨٩) من سطح بـ ج
 يكون على هذه النسبة، فمحرف ادكـ بـ (٩٠) جزآن من أحد عشر جزءا من مربع
 ابـ جد. ولأن نسبة محرف ادكـ بـ (٩٠) إلى محرف جدكـ بـ كنسبة قاعدة بـ كـ
 إلى قاعدة لبـ دـ وبالمقدار الذي به بـ كـ اثنان فلبـ دـ خمسة لأنه (٩١) مثله ومثل
 نصفه فبكون محرف جدكـ بـ خمسة أجزاء من أحد عشر جزءا من المربع الكبير
 ولأن نسبة مثلث اسـ دـ (٩٢) المساوي لمستطيل حـ ي (٩٣) إلى مثلث جـ لا (٩٤) كنسبة
 قاعدة صـ ذـ (٩٥) إلى قاعدة عـ لا. وهو مثلال ونصف، فيكون مثلث حـ عـ لا /
 مثلي ونصف (٩٦) اسـ دـ (٩٧) ومجموعهما ثلاثة أمثال ونصف مستطيل حـ ي (٩٨). ولأن
 مستطيل آلا مركب من صرب ضلع المربع الكبير في جزأي اسـ وأحدهما (٩٩) مثل
 ونصف بـ ي والأخر ثلاثة أمثال ونصف حـ س (١٠٠) وذلك يساوي مجموع المثلثين
 < ومنحرف جـ عـ ذا > - فإذا فصلنا المثلثين من سطح آلا فكانا قد فصلنا مه
 سطح ضلع المربع الكبير في ثلاثة أمثال ونصف حـ س (١٠١). فيكون محرف جـ عـ دا (١٠٢)
 مساويا لضرب ضلع المربع الكبير في مثل ونصف بـ ي. فمحرف جـ عـ ذا (١٠٣) مثل
 ونصف سطح بـ س أي منحرف ادكـ بـ (١٠٤)، بالمقدار الذي به يكون منحرف (١٠٥) /
 جدكـ بـ خمسة يبقى (١٠٦) سطح عـ لـ كـ دـ (١٠٧) واحدا (١٠٨)، وهو واحد وهو المطلوب.

والأموال من كرم المخذوم والمنعم أدام الله علوه أن ينعم بالنظر (١٠٩) والتأمل في

- ٨٨- ل. وإد ٨٩- ل. رس ٩٠- ك. ل. اظكيب ٩١- ك. ل. ل. ل. شيه
 ٩٢- ك. ل. اصط ٩٣- ك. ل. حى ٩٤- ك. ل. وع لا ٩٥- ك. ل. صرط
 ٩٦- ك. : اصابها السخ في هاش ٩٧- ك. ل. حى ٩٨- ك. ل. اهدما
 ٩٩- ك. ل. ح س ١٠٠- ك. ل. حط ا ١٠١- ح ط ا ل. ح ط ا
 ١٠٢- ك. اظكيب ل. اظكيب ١٠٣- ك. ل. ومحرف ١٠٤- ك. ل. وبغى
 ١٠٥- ك. : لب كيب ط ل. : لب كيب ط لب كيب ط ١٠٦- ك. ل. : واحد
 ١٠٧- ك. ل. الاصل والمعروف أن فعل «أعم» يعنى يتعمق يقال «أعم النظر في كذا»- افسر معجم «مى الله»

الآخر أربعة و ٣٠ من ٥٥ من الواحد وهو سطح ع ك الباقي . ولأن سطح خ ص (٦٣)
هو (٦٤) ضرب آخ (٦٥) في اس (٦٦) و اح (٦٧) يساوي ب ك ب وهو واحد وتسعة
أجزاء من أحد عشر جزءا من واحد مع زيادة ح س (٦٨) أي ر س - وضع آف (٦٩)
هو (٧٠) مثل ونصف ب ي مع ثلاثة أمثال ونصف ر س فبرهان (٧١) أشكال المقالة الثانية
من أقليدس يكون ضرب اح (٦٧) في اص (٦٩) يساوي سطح اص (٦٩) في اس (٦٩) و سطح
اص في ح س (٦٨) . ولأن أحد قسمي اص (٦٩) مثل ونصف اس وقسمه الآخر ثلاثة
أمثال ونصف س ح (٦٨) سطح (٧٢) اص (٦٩) في اس يساوي مجموع (٧٣) سطحين
أحدهما <ثلاثة أنصاف مربع> اس - وهو واحد وتسعة أجزاء من أحد عشر فيكون
تكبيره (٧٤) أربعة و ٢٩٠٠ من ٣٠٢٥ والسطح الآخر هو (٧٥) ثلاثة أمثال ونصف ر س
في س وهو سطح يكون أحد ضلعيه ر س والآخر ستة و (٧٦) ٢٥ من ٥٥ . أما سطح
اس في ر س فينحل (٧٧) أيضا إلى ضرب جزأي اص (٧٨) في ر س (٧٩) أي إلى (٧٩) ضرب
اثنين وثمانية أجزاء من أحد عشر جزءا من واحد في ر س - فيحصل (٨٠) سطح أحد ضلعيه
ر س والآخر اثنان وثمانية أجزاء من أحد عشر من واحد - وإلى سطح ر س في ثلاثة
أمثاله ونصف فيحصل ثلاثة مربعات / ر س ونصف مربعه . فحصل لنا <من>
جميع أجزاء ح س (٨١) سطح تكبيره أربعة و ٢٩٠٠ من ٣٠٢٥ من واحد و سطحان آخران
مجموعهما سطح أحد ضلعيه ر س وضلعه الآخر <ضعف> أربعة و ٣٠ من ٥٥
من واحد وثلاثة مربعات ونصف مربع ر س . فإذا أضفنا يكون نصفها مساويا لأجزاء
سطح ح ي (٨٢) المستطيل . ولأن (٨٣) سطح ح س (٨٤) إذا فصل منه مستطيل ح ي (٨٢)
يبقى مستطيل س ب وإذا فصل منه مئالت اح د (٨٥) يبقى منحرف اذ ك ب (٨٦)
فيكون مستطيل س ب مساويا لمنحرف اذ ك ب (٨٧) . ولأن ب ي واحد وتسعة أجزاء

٦٣- ك، ل، ح، ص	٦٤- ك، ل، وهو	٦٥- ك، ل، اح	٦٦- د، ا، اس
٦٧- ك، ل، د، ح	٦٨- ك، ل، ح، س	٦٩- ك، ل، ص	٧٠- د، ل، وهو
٧١- د، ل، مرهون	٧٢- ل، كرر السامع كتبها	٧٣- ل، فوق السطر	٧٤- د، ل، تكبير
٧٥- ك، ل، وهو	٧٦- ل، ناقصة	٧٧- ك، ل، يحس	٧٨- ل، ا، اص
٧٩- ك، ل، أما	٨٠- ك، ل، يحصل	٨١- ك، ل، ح، ص	٨٢- ك، ل، ح، ي
٨٣- د، ل، لأن	٨٤- ك، ل، ح، ب	٨٥- ك، ل، ا، ح، ط	٨٦- ك، ل، ا، ط، ك، ب
٨٧- ك، ل، ا، د، ك، ب			

ولأن مـى ضعف وب (٤٠) و حـى ٣٠٢٥ (٤١) أمثال حـى وب و ٧٢٥ أمثاله ونسبة نـم إلى مـى كسبة يدعى (٤٢) إلى حـى فيكون نـم ٧٢٥ جزءا بالمقدار الذي < نـم > يكون مـى ٣٠٢٥ - وهو ضعف وب ، وبالمقدار الذي < نـم > يكون وب ٣٠٢٥ فيكون نـم ١٤٥٠ .

وقد ذكرنا أن لـ مثل وثلاثة أرباع بـ الواحد ، فسطح لـ (٤٣) < في لـ هو سطح مـى > - الذي هو اثنان - و مـن (٤٤) - وهو ١٤٥٠ (٤٥) من ٣٠٢٥ من الواحد (٤٦) - في لـ الذي هو واحد وثلاثة أرباع ، فيكون (٤٧) تكسيرة أربعة < و > ١٠٢٥ من ٣٠٢٥ من واحد - وهو تكسير مربع كى لأن ضرب نـى في لـ يساوي مربع كى . ولأن سـف ضعف (٤٨) كى و صـى (٤٩) نصف سـف يكون صـى -سا يساوي كى ومربعه مربعه ، ومربع مـ فى يساوي سـف في (٥٠) قـع فيكون تكسير سطح سـف في قـع أربعة و ١٠٢٥ من ٣٠٢٥ من واحد. ولأن قـش ثلاثة بالمقدار (٥١) الذي به يكون ثـرت (٥٢) أربعة ونسبة سـر إلى رـق كذلك فيكون رـق ثلاثة أسباع قـس و رـس أربعة أسباعه . فيكون سطح عـق في رـس أربعة أسباع عـق في (٥٣) قـس المذكور تكسيهه ، و سطح عـق في رـس هو (٥٤) سطح عـث لأن قـس يساوي سـح (٥٥) و سـح (٥٥) مثل سـر . فسطح عـث اثنان و ١٤٥٠ من ٣٠٢٥ و سطح رـح (٥٦) مربع رـس (٥٧) و سطح رـث ثلاثة أرباع مربعه . ولأننا فصلنا سـع خمسة [و ٢٥ من خمسة] (٥٨) و ٢٥ من ٥٥ / < من > واحد يبقى عـى من (٥٩) تمام العشرة أربعة و ٣٠ من ٥٥ من واحد . فجميع سطح حـى (٦٠) المستطيل يساوي مربع رـس - وهو سطح رـح (٦١) - وثلاثة أرباع مربعه - وهو سطح رـث - و سطحاً تكسيهه اثنان ١٤٥٠ من ٣٠٢٥ من واحد - وهو (٦٢) سطح ثـع - و سطحاً أحد ضلعيه رـس وصلعه

- ٤١ - لـ : حـى ١١ لـ ١٠٢٥ ٤٢ - لـ يدى ٤٣ - لـ : حـى ٤٤ - لـ : حـى ٤٥ - لـ : حـى ١٤٥٠ ٤٦ - لـ : واحد ٤٧ - لـ : كـ : كـ : لـ : يكون ٤٨ - لـ : ضعيف ٤٩ - لـ : حـى ٥٠ - لـ : و ٥١ - لـ : كـ : بالمقدار ٥٢ - لـ : كـ : لـ : ثـرت ٥٣ - لـ : ناقصة ٥٤ - لـ : كـ : لـ : وهو ٥٥ - لـ : كـ : لـ : سـح ٥٦ - لـ : كـ : لـ : رـح ٥٧ - لـ : رـكـه ٥٨ - رائده في لـ : حـى ٥٩ - لـ : كـ : لـ : حـى ٦٠ - لـ : كـ : لـ : حـى ٦١ - لـ : كـ : لـ : رـح ٦٢ - لـ : كتبها التاسخ فوق السطر .

ونخرج من نقطة ح (١٨) خطا يوارى خط بـ وهو خط حـ ي (١٩) ثم نخرج من نقطة ي خط ي س يوارى ا ب ونخرج (٢٠) خط س ي على استقامته إلى نقطة ل حـ ي (٢١) يكون خط ي ل مثل بـ و ثلاثة أضعافه . ويجعل ي م مثل (٢٢) بـ و . ثم يتعمد نقطة جـ ب ونجعل خط جـ حـ ٣٠٢٤ مثل خط ي حـ . ثم نجعل خط حـ د ٧٢٥ أمثالا لخط ي حـ ونصل خط حـ د ونخرج خط بدن موازيا له وندير على قطر د ل نصف دائرة ثم نجعل خط س ح خمسة أمثال (٢٣) وخمسة أجزاء من أحد عشر ■ جزءا من خط بـ و . ولأن قطر س ح أعظم من قطر د ل فلما أن نخرج من نقطة س في دائرة س ح وتر مساويا لصنف كـ ي وهو س ي . ونقسم قوس س ي نصفين على صـ ونخرج من نقطة ص عمودا ص ق ثم نجعل نقطة ش على ص ق كيف < ما > وقعت . ونجعل (٢٤) ش ت مثل وثلاث ف ش ونصل (٢٥) خط ت س (٢٦) ونخرج من ش خط ن ر موازيا له ونجعل س ح (٢٧) مثل س ر ونخرج ح ك يوارى آ ب ثم نجعل د ك مثل ونصف ب ك ونخرج ل ب يوارى آ ب ونجعل أ ص مثل ونصف ب ي مريداً عليه ثلاثة أمثال ونصف ي ك ونخرج ص ل ثم نخرج آ ذ (٢٨) ح ع (٢٩) .

فأقول إن المربع قد انقسم على الجهة المطلوبة وهي أن منحرف ا ب د ك (٣٠) صنف سطح د ع ب ك (٣١) ومنحرف ا د حـ (٣٢) خمسة (٣٣) أمثاله ومنحرف د ذ ل عـ (٣٤) ثلاثة (٣٥) أمثاله (٣٦) .

برهان ذلك . لأن ب ط عشرة أمثال بـ و وستة د ب إلى بـ و كنيسة ط ب إلى بـ و فيكون د ب عشرة أمثال بـ و ويسميه الواحد . ولأن ر ب ٥٥ أمثال ب ط (٣٧) و ر حـ ٤٥ مثلاً له يكون نسبة ر ب إلى ر حـ كنيسة ٥٥ إلى ٤٥ ونسبة (٣٨) بـ و إلى و ي كنيسة ٥٥ إلى ٤٥ (٣٨) فيكون و ي تسعة أجزاء على (٣٩) أن و ب الواحد أحد عشر جزءا .

١٨ - ل ك حـ ١٩ - ل ك ل حـ ي ٢٠ - ل ونخرج س ٢١ - ل إلى أ ٢٢ - ل ش
٢٣ - ل ك ل أش ل ٢٤ - ل ك ل ويريد عليه ٢٥ - ل ونخرج ٢٦ - ل ك ل ش س
٢٧ - ل ك ل س حـ ٢٨ - ل ك ل ط ل حـ ٢٩ - ل حـ ٣٠ - ل ك ل ا ب ط ك ب
ل ا ب ط ك ب ٣١ - ل ك ل ط ل حـ ك ب ل ص حـ ل ك ب ٣٢ - ل ك ل ا ط حـ
٣٣ - ل ل ثلاثة ٣٤ - ل ك ل حـ د ل عـ ٣٥ - ل ك ل حـ حـ ٣٦ - أي أش ل المستطيل
٣٧ - ل ب ط ٣٨ - ٣٨ ما بينهما السطح في ل ثم أعاد كثرته في الماش ٣٩ - ل د ناقصة

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ (١)

الحمد لله رب العالمين والصلوة والسلام على رسوله محمد وآله أجمعين

مسألة (٢) سألها شمس الدين * أمير الأمراء النظامية عن الإمام الأجل الأوحد العالم شرف الدين بهاء الإسلام حجة (٣) الزمان مظفر (٤) بن محمد (٥) المطهر الطوسي أدام الله توفيقه ببلد همدان سنة ست (٦) وستمائة (٧) هجرية .

عن مربع متساوي الأضلاع كل ضلع منه معلوم وأردنا أن نقسمه إلى أربعة (٨) سطوح (٩) أحدها (١٠) سطح متواري الأضلاع مستطيل ، في الوسط ، وثلاثة منحرفات (١١) تحيط به (١٢) من ثلاثة جوانب على (١٣) هذا المثال على وجه تكون السطوح الأربعة بعضها إلى بعض < على > نسبة مفروضة معلومة وقد عيّن ضلع المربع ونسبة السطوح . يقال كل ضلع من أضلاع المربع عشرة والمطلوب أن يكون السطح المتواري الأضلاع الذي في الوسط نصف المنحرف الذي على أحد (١٤) جانبيه والمنحرف الذي فوقه ثلاثة أمثاله والمنحرف الذي على الجانب الآخر منه خمسة أمثاله .

مثال ذلك : مربع ا ب ج د متساوي الأضلاع وصلح ا ب عشرة وأردنا العمل المذكور ، فنخرج ضلع < ا ب > على استقامته ويتعلم عليه نقطة هـ . كيفما اتفقت (١٥) ونزيد على خط ب هـ تسعة أمثاله فيكون خط ب ط عشرة أمثال خط ب هـ ونصل ط د ونخرج من نقطة د خط هـ و وبوازي ط د ثم يتعلم نقطة ط على خط ب هـ . نقطة ط كيفما وقعت (١٦) . ونجعل ط ز هـ مثل ب ط (١٧) ونخط ز ح (١٨) مثل ب ط ونصل ز و /

١ - ب : تعيّن " وبه تفق " ٢ - ك : مثله ٣ - ك : حسب ٤ - ب : كتبها
السامع أولاً " عند " ثم كتب فيها بط مظهر فوقها . ٥ - ك : ناقصة ولي ب . ستة
٦ - ك : وحسب ما به ٧ - ك : ل : أربع ٨ - ل : اسطوح ٩ - ب : كتبت أولاً واحداً
ثم رجعت إلى السامع وكتب فوق " هـ " " هـ " ١٠ - ل : متحرفات ١١ - ك : ل : هـ
١٢ - ل : على كل ١٣ - ب : ناقصة ١٤ - ل : اتفق ١٥ - ل : بدأ السامع بكتابه وقعت ثم عدت عن
هذا وكتب اتفقت ١٦ - ل : بط ، ك : ب ط ١٧ - ل : ك : ز ح
* من الواضح أن هذا لقب ، ولم يند إلى مرتبته من الدراسات التي رخصا إليه عن ألبترسة النظامية .

تقديم

لقد حققنا نص شرف الدين الطوسي على مخطوطين :

الأولى هي مخطوطة جامعة كولومبيا Smith MS. Or. 47 من صفحة ٢٩ إلى صفحة ٣٥ وهي مخطوطة من القرن الثالث عشر حسب تقدير مصنف مخطوطات مكتبة جامعة كولومبيا . ولقد أشرنا بحرف ك إلى هذه المخطوطة

الثانية هي مخطوطة ليدن Or. 14 من صفحة ٢٢٣ وحده إلى ٣٢٦ ظهر . ومن المعروف من مهارست دورى أن هذه المخطوطة قد نُسخَت في القرن السابع عشر وسنشير هنا بحرف ل . وسنبين في تحقيقنا لحر عمر الخيام أصلها ، ويكفيها الآن أن نقول إن المخطوطين ترحمان إلى نفس الأصل بل من المؤكد أن مخطوطة كولومبيا هي أقرب إلى الأصل للأسباب التالية

- ١ - باستثناء ثلاثة أخطاء في ك نجد كل أخطاء ك مع كثرتها في ل والعكس غير صحيح .
- ٢ - ينقص ل خمس كلمات بخلاف ك فيما ينقص ك كلمة واحدة موحودة في ل
- ٣ - كل ما يجب إضافته إلى ك من كلمات وعبارات حتى يستقيم المعنى يجب أيضا إضافته إلى ل .

والمخطوطين تحتويان على أخطاء عديدة زارها الخلط بين حروف الرسم الهندسي واستعمال نفس الحرف ظ للدلالة على نقطتين مختلفتين في الرسم

واستعملنا الرموز التالية في التحقيق :

<	ما بينهما كلامنا
[]	نقترح حذف ما بينهما
/	انتهاء صفحات ك
■	انتهاء صفحات ل

وأغلب النص غير منقوط ولقد قمنا بتنقيطه دون الإشارة إلا إذا تعددت الاحتمالات فأشأنا نص المخطوطة في أسفل الصفحة ، ولقد أعدنا الرسم حتى يوافق النص .

est égal au rapport de la base $B\Delta$ à la base ΠD , suivant la quantité qui rend $B\Delta$ égal à deux, alors ΠD est cinq, car il est égal à deux fois et demie celui-ci; on a donc le trapèze $CD\Pi\Omega$ cinq parties de onze parties du grand carré. Puisque le rapport du triangle AXZ , qui est égal au rectangle WJ , au triangle $C\Omega\Pi$, est égal au rapport de la base λZ à la base $\Omega\Psi$, qui est deux et demi,¹ le triangle $C\Omega\Pi$ ■ est donc deux fois et demie AXZ , et leur somme est trois fois et demie le rectangle WJ .

Puisque le rectangle $A\Psi$ est composé du produit du côté du grand carré par les deux parties de AX , dont l'une est une fois et demie BJ et l'autre est trois fois et demie WS , et que ceci est égal à la somme des deux triangles plus le trapèze $C\Omega ZA$, si donc on sépare les deux triangles de la surface $A\Psi$, cela revient à en séparer la surface < obtenue > du côté du grand carré par trois fois et demie WS . On a donc le trapèze $C\Omega ZA$ égal au produit du côté du grand carré par une fois et demie BJ . On a donc le trapèze $C\Omega ZA$ une fois et demie la surface BS , soit la surface $AZ\Delta B$; suivant la quantité qui rend le trapèze $CD\Pi\Omega$ égal à cinq, il reste la surface $\Omega\Pi\Delta Z$ égale à un. Elle est donc un, ce qui est cherché.

On attend de la générosité du Seigneur Bienfaiteur – que Dieu perpétue son Eminence – qu'il examine et médite cette proposition, et pardonne les petites négligences, seulement si elles ont lieu dans certains de ses calculs particuliers.

S'il rencontre une erreur dans certaines de ses démonstrations, qu'il nous avertisse, cela sera utile à la question qu'il pose, car nous aurions été aveuglé par la multiplicité des prémisses, et par le mélange des prémisses géométriques à l'arithmétique; et qu'il ne blâme pas la longueur excessive de ces prémisses, car atteindre ■ l'objet d'une recherche démonstrative, par la multiplicité des prémisses et des propositions intermédiaires, tout en se préservant de l'erreur, si on s'en préserve,² cela se fera par l'habitude et par l'exercice. Et j'indique qu'atteindre le but dans les sciences théoriques augmente nécessairement les prémisses de leurs démonstrations, et leurs propositions intermédiaires. Ce sont là les plus grands enseignements des sciences mathématiques.

Certes, j'ai évité de m'étendre sur les prémisses des démonstrations de cette proposition, bien qu'elles soient véritablement nécessaires pour mener avec profit au résultat cherché.

Si par la suite le Seigneur Bienfaiteur en exprime le désir, j'exposerai les différentes méthodes à son éminent jugement critique, si Dieu le veut.

Que la paix soit.

1. Littéralement: deux fois plus un demi.

2. Littéralement si cela est.

est le carré de RS , et la surface RV est trois quarts de ce carré. Mais comme on a séparé SO égal à cinq plus vingt-cinq cinquantièmes, d'unité, il reste de dix entiers OJ égal à quatre plus trente cinquante cinquantièmes.

Le rectangle WJ tout entier est égal au carré de RS , qui est la surface RW plus les trois quarts de son carré, qui est la surface RV plus une surface dont la mesure est deux plus mille quatre cent cinquante trois mille vingt cinquantièmes d'unité, qui est la surface VO et une surface dont un côté est RS et l'autre côté est quatre plus trente cinquante cinquantièmes d'unité, qui est la surface $O\Delta$ restante.

Puisque la surface WX est le produit de AW par AX et que AW est égal à BD qui est un plus neuf parties de onze parties d'unité, augmenté de SW , soit RS , et que le côté AX est une fois et demie BJ plus trois fois et demie RS , alors, par la démonstration des propositions du Livre II d'Euclide, on a le produit de AW par AX égal à la surface AX par AS plus la surface AX par WS . Puisque l'une des deux parties de AX est une fois et demie AS , et que l'autre partie est trois fois et demie SW , la surface AX par AS est égale à la somme des deux surfaces, dont l'une est trois demies du carré de AS qui est un plus neuf parties de onze parties, et sa mesure est donc quatre plus deux mille neuf cent trois mille vingt cinquantièmes; l'autre surface est trois fois et demie RS par AS , qui est une surface dont l'un des deux côtés est RS , et l'autre est six plus vingt-cinq cinquante cinquantièmes.

Quant à la surface AX par RS , elle se décompose également en les produits des deux parties de AX par RS ■, soit en le produit de deux plus huit parties de onze parties d'unité par RS — on obtient donc une surface dont un côté est RS , et l'autre est deux plus huit parties de onze parties d'unité; et en la surface de RS par trois fois et demie lui-même, — on obtient trois carrés / de RS plus la moitié de son carré.

On obtient donc de toutes les parties de WX une surface dont la mesure est quatre plus deux mille neuf cents trois mille vingt cinquantièmes, plus deux autres surfaces dont la somme est une surface dont l'un des côtés est RS , et l'autre côté le double de quatre plus trente cinquante cinquantièmes d'unité, plus trois carrés de RS et la moitié de son carré. Si on additionne le tout, on a la moitié égale aux parties du rectangle WJ . Puisque si de la surface WB , on sépare le rectangle WJ , il reste le rectangle SB , et si on en sépare le triangle AWZ , il reste le trapèze $AZ\Delta B$, on a alors le rectangle SB égal au trapèze $AZ\Delta B$. Puisque BJ est un plus neuf parties de onze parties, et que sa moitié est dix parties de onze parties d'unité, et que si on divise les dix en onze parties, chaque partie sera dix parties de onze parties d'unité, alors BJ est deux parties de onze parties de BD , qui est dix, et la surface BS à la surface BC est dans le même rapport; alors le trapèze $AZ\Delta B$ est deux parties de onze parties du carré $ABCD$; mais puisque le rapport du trapèze $AZ\Delta B$ au trapèze $CD\Pi Q$

abaïssons la perpendiculaire UQ et marquons le point Ξ sur UQ peu importe où il se trouve et posons ΞT égal à une fois plus un tiers $Q\Xi$, et joignons TS ; menons de Ξ la droite ΞR parallèlement à elle. Posons SW égal à SR . Menons $W\Delta$ parallèle à AB . Posons ensuite $D\Pi$ deux fois et demie $B\Delta$. Menons $\Pi\lambda$ parallèle à AB . Posons AX une fois et demie BJ , augmenté de trois fois et demie $J\Delta$. Menons $X\Upsilon$ et menons ensuite AZ , $C\Omega$. Je dis alors que le carré a été divisé de la manière cherchée, c'est-à-dire que le trapèze $ABZ\Delta$ est deux fois la surface $Z\Omega\Pi\Delta$, le trapèze $AZ\Omega C$ est son quintuple, et le trapèze $CD\Pi\Omega$ est son triple.

Démonstration.

Puisque BI est dix fois BE , et que le rapport de DB à BF est égal au rapport de IB à BE , on a donc DB dix fois BF , on l'appelle alors l'unité. Puisque GB est 55 fois BY_1 , et GH 45 fois celui-ci, on a le rapport de GB à GH égal au rapport de 55 à 45, et le rapport de BF à FG est égal au rapport de 55 à 45.

On a donc FJ égal à neuf parties, étant donné FB , l'unité, onze parties. Puisque MJ est le double de FB , et que ΣJ est 3025 fois $J\Theta$, et que $\Gamma\Sigma$ est 725 fois celui-ci, et que le rapport de NM à MJ est égal au rapport de $\Gamma\Sigma$ à ΣJ , on a NM 725 parties, suivant la quantité qui rend MJ égal à 3025. Mais $\langle MJ \rangle$ est le double de FB ; on a alors NM égal à 1450, suivant la quantité qui rend FB égal à 3025.

Mais on a indiqué que JF est une fois plus trois quarts BF , l'unité. Donc la surface JN par JL est la surface de MJ qui est deux plus MN qui est mille quatre cent cinquante trois mille vingt cinquièmes d'unité,¹ par JL qui est un plus trois-quarts; sa mesure est donc 4 plus mille vingt-cinq trois mille vingt cinquièmes d'unité, qui est la mesure du carré de KJ , car le produit de NJ par JL est égal au carré de KJ . Puisque SP est le double de KJ et que UQ est la moitié de SP , on a UQ égale KJ , et leurs carrés sont égaux. Le carré de KJ est égal à SQ par QO ; on a donc la mesure de la surface SQ par QO 4 plus mille vingt-cinq trois mille vingt cinquièmes d'unité. Puisque $Q\Xi$ est trois suivant la quantité qui rend ΞT égal à quatre, et que le rapport de SR à RQ est le même, on a donc RQ trois septièmes de QS , et RS est ses quatre septièmes. On a donc la surface OQ par RS quatre septièmes de OQ par QS , dont on a rappelé la mesure; et la surface OQ par RS est la surface OV , car QV est égal à SW et SW égale SR , donc la surface OV est deux plus mille quatre cent cinquante trois mille vingt cinquièmes, et la surface RW

1 Littéralement 1450 de 3025 de l'unité, formulation difficilement intelligible en français. Nous avons adopté, dans ce cas comme dans les autres semblables, des traductions équivalentes à celle donnée ci-dessus, quitte à changer les chiffres en mots.

Traduction

Au nom de Dieu Clément et Miséricordieux. Grâces lui soient rendues, et bénédiction à Muḥammed son prophète, et à toute sa famille.

Problème posé par Shams al-Din, Prince des Princes de al-Nizāmiyya, au très illustre et unique Imām, Sharaf al-Din, gloire de l'Islam, figure de l'Histoire,¹ Muzafar bin Muḥammed al-Muzafar al-Tūsī, que Dieu perpétue sa réussite.

Dans la ville de Hamadān, l'année six cent six de l'Hégire.

Au sujet d'un carré dont chacun des côtés est connu, et qu'on veut partager en quatre surfaces. L'une, au milieu, est un rectangle, et trois trapèzes l'entourent de trois côtés, de sorte que les quatre surfaces sont les unes aux autres dans un rapport donné connu. Que le côté du carré et le rapport des surfaces soit déterminé: disons que chacun des côtés du carré soit dix; ce qu'on cherche est que le rectangle qui est au milieu soit la moitié du trapèze qui est sur l'un de ses côtés, que le trapèze qui est au-dessus de lui soit son triple, et que le trapèze qui est sur l'autre côté soit son quintuple.

Exemple: le carré $ABCD$ a des côtés égaux, et le côté AB est dix, et on veut la construction indiquée.

Prolongeons le côté AB jusqu'à un point E quelconque, et ajoutons à la droite BE neuf fois elle-même: on a donc la droite BI dix fois la droite BE . Joignons ID , et menons du point E la droite EF , parallèle à ID . On marque un point Y sur la droite BE — peu importe où se trouve Y .

Posons YG 54 fois BY , et GH 45 fois BY : joignons GF . Menons du point H une droite parallèle à la droite GF , qui est la droite HJ . Menons ensuite du point J la droite JS , parallèle à AB , et prolongeons SJ jusqu'au point L , de sorte que la droite JL soit égale à BF plus ses trois-quarts.

Posons JM deux fois BF , et marquons ensuite le point 1 , posons la droite $^1\Sigma$ 3024 fois la droite J^1 , et posons ensuite la droite Σ^1 725 fois la droite J^1 .

Joignons la droite ΣM , et menons la droite 1N parallèle à celle-ci. Traçons sur le diamètre NL un demi-cercle, et posons ensuite la droite SO cinq fois plus cinq parties de onze \blacksquare parties de la droite BF . Puisque le diamètre SO est plus grand que le diamètre NL , on peut donc mener du point S dans le cercle SO une corde, SP , égale au double de KJ .

Partageons l'arc SP en deux parties égales, au point U . Du point 1

1. Littéralement: preuve du temps.

dans ce type de problèmes de construction géométrique à la règle et au compas, mais traité par un algébriste, deux traductions successives: une traduction algébrique du problème géométrique, qui ramène à une équation algébrique; une traduction géométrique du problème algébrique, destinée à répondre au problème initial par une construction (l'intersection d'un cercle et d'une droite).

Cette notable différence entre la solution des problèmes de construction géométrique traités par les algébristes, et l'étude des mêmes problèmes par les géomètres - le célèbre problème de la trisection de l'angle, par exemple - tient à cette double traduction. Elle n'exprime pas seulement de nouveaux rapports entre algèbre et géométrie, mais encore elle infléchit le sens même du terme d'analyse dans un débat célèbre sur l'analyse et la synthèse.

Mais une telle démarche n'apparaît pas pour la première fois chez al-Tūsī; elle est déjà suivie par ses prédécesseurs, al-Khayyām par exemple, pour traiter de problèmes plus difficiles que celui d'al-Tūsī, comme la division d'un quart de cercle en deux parties en un point, sous certaines conditions; ceci fera l'objet d'une prochaine étude.

Préface à la Traduction

Le texte que nous présentons ainsi que sa traduction a été établi à partir de deux manuscrits:

1. Smith MS. Or. 47, Columbia University, pp. 29-35. Vraisemblablement copié au XIII^{ème} siècle.

2. Leiden Or. 14, ff. 323^r - 326^v. Copié au XVII^{ème} siècle à la demande de Golius. Voir le catalogue de Dozy.

Les deux textes renvoient au même archétype pour les raisons suivantes:

(1) Sur 116 accidents, on en trouve seulement 3 dans le manuscrit de Columbia qui ne soient pas dans le manuscrit de Leiden, la réciproque n'est pas vraie: des dizaines d'accidents figurent simplement dans ce dernier.

(2) Il manque au manuscrit de Leiden cinq mots que l'on trouve tous dans le manuscrit de Columbia; tandis qu'il manque à ce dernier un seul mot qui figure dans le premier.

(3) Ce qu'il faut ajouter pour établir le sens du texte est nécessaire dans les deux cas.

Enfin, plusieurs accidents sont provoqués par l'usage d'une même lettre pour désigner deux points différents de la figure géométrique.

Nous avons indiqué les pages du manuscrit de Columbia par / et celles du manuscrit de Leiden par ■.

Mais pour achever l'analyse, il faut encore pouvoir placer la droite δ . Il est donc nécessaire de procéder à une deuxième construction pour obtenir un segment de longueur l telle que

$$l^2 = \frac{525}{11^2}$$

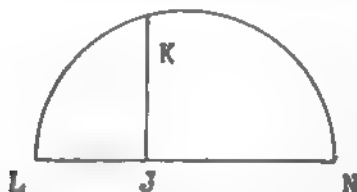
On détermine alors l comme moyenne géométrique entre les deux longueurs l_1, l_2 telles que:

$$l_1 \cdot l_2 = \frac{525}{11^2} \quad , \quad l_1 \text{ et } l_2 \text{ rationnels.}$$

Al-Tūsī fait pour l_1 et l_2 le choix suivant:

$$l_1 = JL = \frac{7}{4} \quad \quad l_2 = JN = \frac{300}{121}.$$

On retrace le cercle de diamètre LN et on obtient le segment JK de longueur l en utilisant la puissance du point J par rapport au cercle.



Telle est, nous semble-t-il, la voie de l'analyse qu'a suivie al-Tūsī. Elle nous permet de comprendre comment il a choisi les valeurs numériques particulières rencontrées dans la synthèse du problème, ainsi que les étapes successives de cette synthèse. On saisit en effet les raisons des différentes constructions et on comprend l'ordre de leur enchaînement.

Rien dans cette analyse ne peut surprendre: les notions et les techniques auxquelles elle fait appel sont parmi les plus élémentaires rencontrées dans son *Traité sur les Equations*.

Ainsi, après avoir tout d'abord suivi la voie d'une analyse algébrique pour étudier les inconnues x, y, z, t , il procède par une technique partout utilisée dans son *Traité*: les exprimer toutes au moyen des transformations affines d'une seule inconnue u . La traduction par des constructions géométriques des éléments de l'analyse algébrique donne ensuite la solution du problème géométrique posé.

Si l'hypothèse que nous venons de développer est juste, on rencontre

d'où
$$y = \frac{80}{11} - \frac{7}{2} u.$$

D'autre part

$$AX = 10 \quad y = \frac{30}{11} + \frac{7}{2} u,$$

d'où
$$AX = \frac{3}{2} BJ + \frac{7}{2} J\Delta.$$

Il est donc clair que la solution du problème revient à la détermination de u .

$$S, \quad \frac{100}{11} \iff xy = \frac{100}{11} \iff \left(\frac{40}{11} - \frac{7}{2} u\right) \left(\frac{80}{11} - \frac{7}{2} u\right) = \frac{100}{11},$$

d'où
$$\left(\frac{7}{2} u\right)^2 - \frac{60}{11} \left(\frac{7}{2} u\right) + \frac{525}{11^2} = 0, \quad \text{avec } \frac{7}{4} u < \frac{20}{11},$$

d'où
$$\frac{7}{4} u = \frac{60 - \sqrt{375}}{11}.$$

On a donc retrouvé par l'analyse précédente la plupart des valeurs numériques d'al-Tūsī. Mais la résolution algébrique de l'équation du second degré obtenue conduit à un nombre irrationnel, et ne pouvait par conséquent constituer une réponse au problème de construction posé. L'analyse exige donc que l'on détermine les deux racines de l'équation par des moyens pour ainsi dire constructifs; l'intersection d'un demi-cercle et d'une droite. Le cercle a nécessairement pour diamètre un segment SO de longueur $\frac{60}{11}$ (somme des racines) et la droite δ doit être telle que sa distance à la droite SO ait pour carré $\frac{525}{11^2}$ (produit des racines).



Mais si l'on tient compte de la condition $\frac{7}{4} u < \frac{20}{11}$, on constate que seule la racine QS convient pour le problème.

Seul, il est vrai, l'examen de la voie de l'analyse suivie par al-Tūsī peut éclairer les raisons de ce choix et de cet enchaînement. Et de fait la lecture de la conclusion de sa réponse est convaincante: le mathématicien y reconnaît l'importance de l'analyse, particulièrement dans ce type de problèmes arithmético-géométriques; il y justifie son silence par des raisons de circonstances, à savoir la recherche délibérée de la brièveté dans sa correspondance.

Al-Tūsī considère en effet que l'analyse est nécessaire pour parvenir au résultat cherché et, plus généralement, qu'elle seule produit "les plus grands enseignements dans les sciences mathématiques". Aussi déclare-t-il à son correspondant que, bien qu'il passe outre et n'expose pas cette analyse, il se tient à sa disposition pour la lui communiquer, s'il en exprime le désir.

Pour nous, cependant, le résultat est le même: le texte ne nous offre aucune information sur l'analyse suivie par le mathématicien. Il ne nous reste qu'à tenter de reconstituer cette analyse à l'aide des seules notions en possession du mathématicien. Reprenons donc le problème d'al-Tūsī et posons:

S_1 = le rectangle $Z\Omega\Delta\Pi$

S_2 = le trapèze $AB\Delta Z$

S_3 = le trapèze $CD\Pi\Omega$

S_4 = le trapèze $AZ\Omega C$

rels que $S_2 = 2 S_1$, $S_3 = 5 S_1$, $S_4 = 3 S_1$.

Posons $\Delta\Pi = x$, $\Delta Z = y$, $\Pi D = z$, $\Delta B = t$

On a immédiatement:

$$S_1 = \frac{1}{11} (A, B, C, D) = \frac{100}{11}$$

$$S_1 = \frac{2}{11} (A, B, C, D) \iff S_2 = (B, J, S, A)$$

avec $BJ = \frac{2}{11}$, $BD = \frac{20}{11}$,

$$S_3 = \frac{5}{2} S_2 \iff D\Pi = \frac{5}{2} B\Delta .$$

Soit $J\Delta = u$, une inconnue auxiliaire, on a

$$t = \frac{20}{11} + u \quad z = \frac{50}{11} + \frac{5}{2} u$$

$$x = 10 - t - z = \frac{40}{11} - \frac{7}{2} u$$

$$S_4 = 3 S_1 \iff \frac{(10 - y)(10 + x)}{2} = 3xy$$

On a donc $(W, J) = \frac{1}{2} (W, X) (A, W, Z)$.

Mais $(W, B) - (W, J) = (B, S)$
 et $(W, B) - (A, W, Z) = (B, \Delta, Z, A)$ $\left\{ \begin{array}{l} \text{d'où } (B, S) = (B, \Delta, Z, A), \end{array} \right.$

Mais $(B, S) = \frac{2}{11} (A, B, C, D)$,

d'où $(B, \Delta, Z, A) = \frac{2}{11} (A, B, C, D)$.

D'autre part les trapèzes (B, Δ, Z, A) et (D, C, Ω, Π) ont des bases égales et leurs hauteurs $B\Delta$ et $D\Pi$ sont dans le rapport $\frac{2}{5}$.

Donc $(D, C, \Omega, \Pi) = \frac{5}{11} (A, B, C, D)$.

On a $(A, Z, \Omega, C) = (A, \Psi) - [(A, X, Z) + (C, \Omega, \Psi)]$

Mais $(C, \Omega, \Psi) = \frac{5}{2} (A, X, Z)$,

d'où $(A, Z, \Omega, C) = (A, \Psi) - \frac{7}{2} (W, J)$
 $= AC \cdot AX - \frac{7}{2} AC \cdot WS$
 $= AC \left(\frac{3}{2} AS + \frac{7}{2} WS - \frac{7}{2} WS \right) = \frac{3}{2} AC \cdot AS$
 $= \frac{3}{2} (B, S) = \frac{3}{11} (A, B, C, D)$.

Finalement, si on retranche du carré (A, B, C, D) les trois trapèzes, il reste le rectangle (Ω, Π, Δ, Z) qui est donc $\frac{1}{11}$ de (A, B, C, D) .

L'exposé d'al-Tūsi, ainsi que le montre le précédent résumé, est strictement synthétique. A aucun moment, ou presque,¹ le mathématicien ne dévoile les raisons pour lesquelles il a choisi les valeurs numériques particulières des différentes constructions. Il n'explique pas davantage l'ordre d'enchaînement de ces constructions.

1 On a $S_1 = \frac{1}{11} (A, B, C, D)$. On a également dès le départ le point J défini par $BJ = \frac{2}{11} BD$, et tel que le rectangle (A, J) soit les $\frac{2}{11}$ du carré; donc (A, J) est égal au trapèze S_2 cherché.

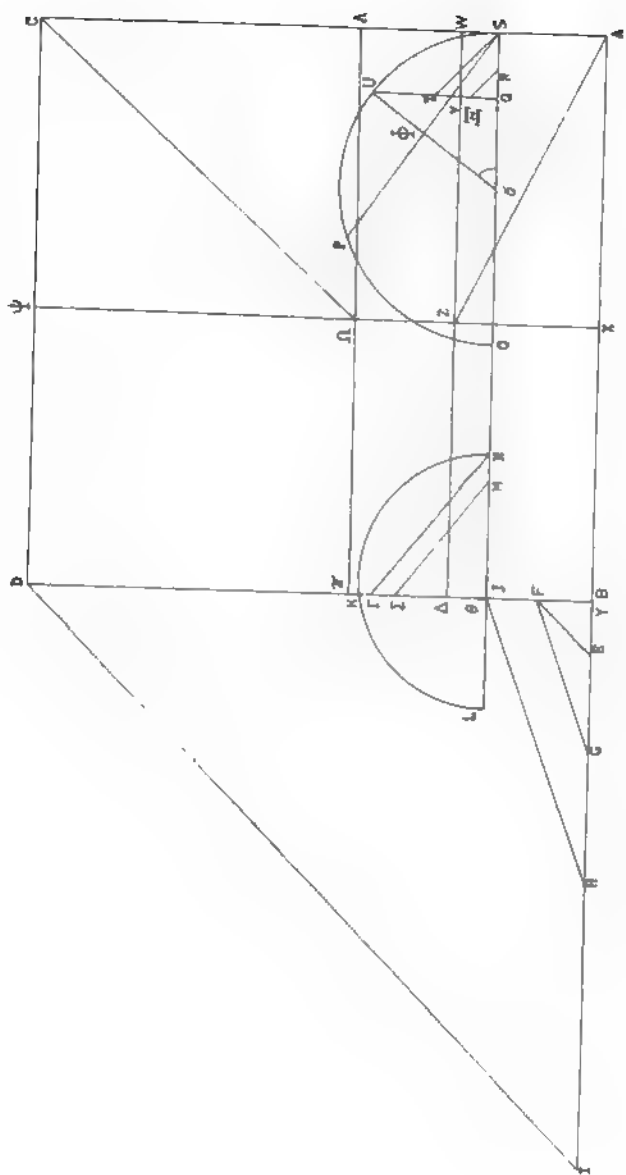


Figure 4:

d'où
$$JN = JM + MN = \frac{300}{121} BF.$$

Mais $JN \cdot JL = JK^2$, puissance de J par rapport au cercle de diamètre NL .

On a
$$JK^2 = \frac{300}{121} \times \frac{7}{4} \overline{BF}^2 = \frac{525}{11^2} \overline{BF}^2.$$

Mais comme $SP = 2KJ$, U est le milieu de \widehat{SP} . $UQ \perp SO$, l'égalité des triangles rectangles $S\alpha\Phi$ et $U\alpha Q$ donne $UQ = S\Phi = \frac{1}{2} SP$ d'où $UQ = KJ$.

On a $SQ \cdot QO = UQ^2$ puissance de Q par rapport au cercle de diamètre SO ,

d'où
$$SQ \cdot QO = \frac{525}{11^2} \overline{BF}^2.$$

D'après la construction de R , on a

$$RQ = \frac{3}{7} QS \quad \text{et} \quad RS = \frac{4}{7} QS.$$

d'où
$$OQ \cdot RS = \frac{4}{7} \cdot \frac{525}{11^2} \overline{BF}^2.$$

Mais
$$OQ \cdot RS = OQ \cdot QV = (O, V)$$

car
$$QV = SW = SR,$$

d'où
$$(O, V) = \frac{4}{7} \cdot \frac{525}{11^2} \overline{BF}^2.$$

On a
$$(W, J) = (W, R) + (R, V) + (V, O) + (O, \Delta)$$

et
$$(O, \Delta) = OJ \cdot J\Delta = OJ \cdot RS \quad \text{avec} \quad OJ = \frac{50}{11} BF,$$

d'où
$$\begin{aligned} (W, J) &= RS^2 + \frac{3}{4} RS^2 + \frac{4}{7} \cdot \frac{525}{11^2} \overline{BF}^2 + \frac{50}{11} BF \cdot RS \\ &= \frac{7}{4} RS^2 + \frac{300}{11^2} \overline{BF}^2 + \frac{50}{11} BF \cdot RS. \end{aligned}$$

D'autre part on a

$$\begin{aligned} (W, X) &= AX \cdot AW = \left(\frac{3}{2} AS + \frac{7}{2} WS \right) (AS + WS) \\ &= \frac{3}{2} AS^2 + 5 AS \cdot WS + \frac{7}{2} WS^2 \\ &= \frac{3}{2} \left(\frac{20}{11} BF \right)^2 + 5 \frac{20}{11} BF \cdot RS + \frac{7}{2} RS^2 \\ &= \frac{600}{11^2} \overline{BF}^2 + \frac{100}{11} BF \cdot RS + \frac{7}{2} RS^2 = 2(W, J) \end{aligned}$$

Traçons ΣM et $LN \parallel \Sigma M$, N sur JS .

$$\text{Posons } SO = 5 BF + \frac{5}{11} BF = \frac{60}{11} BF.$$

Traçons le demi-cercle de diamètre SO et menons de S dans ce demi-cercle une corde SP égale à $2 JK$, ce qui est possible car $SO > LN$.

Soit U le milieu de \widehat{SP} , $UQ \perp SO$.

Soit Ξ arbitraire sur UQ et T tels que

$$\Xi T = \left(1 + \frac{1}{3}\right) Q\Xi \quad \text{avec } \Xi \text{ et } T \text{ sur } QU.$$

Traçons TS et $\Xi R \parallel TS$, R sur SO . Plaçons W sur AC tel que $SW = SR$. De W menons $W\Delta \parallel AB$, Δ sur BD .

Soit Π sur BD tel que : $D\Pi = \left(2 + \frac{1}{2}\right) B\Delta$. Par Π on mène $\Pi\Lambda \parallel AB$, Λ sur AC .

Soit X sur AB tel que :

$$AX = \frac{3}{2} BJ + \left(3 + \frac{1}{2}\right) J\Delta$$

et $X\Psi \parallel BD$, Ψ sur CD .

Soit Z l'intersection de ΔW et $X\Psi$ et Ω l'intersection de $X\Psi$ et $\Lambda\Pi$, on a

le rectangle $Z\Omega\Delta\Pi$

le trapèze $ABZ\Delta$ tel que $(A, B, Z, \Delta) = 2(Z, \Omega, \Delta, \Pi)$

le trapèze $AZ\Omega C$ tel que $(A, Z, \Omega, C) = 5(Z, \Omega, \Delta, \Pi)$

le trapèze $CD\Pi\Omega$ tel que $(C, D, \Pi, \Omega) = 3(Z, \Omega, \Delta, \Pi)$

Démonstration :

BF est l'unité.

La construction de J donne $\frac{BF}{FJ} = \frac{11}{9}$.

d'où $FJ = \frac{9}{11} BF$, $BJ = \frac{20}{11} BF$.

La construction de N donne $MN = \frac{725}{3025} MJ = \frac{1450}{3025} BF$,

$$S_2 = 2S_1, \quad S_3 = 5S_1, \quad S_4 = 3S_1.$$

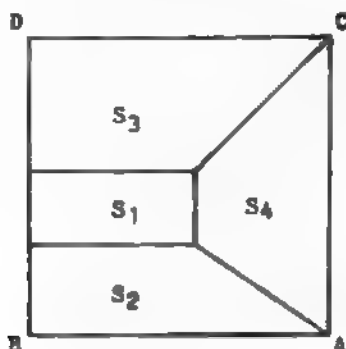


Figure 1

Il s'agit donc d'un problème de construction géométrique à l'aide de la règle et du compas. On peut penser, au premier abord, que ce problème de construction est totalement indépendant des réalisations algébriques d'al-Ṭūsī, telles qu'il les expose dans son *Traité sur les Equations*, et cette impression peut se trouver corroborée par l'exposé purement synthétique du mathématicien.

Toute la question est de savoir dans quelle mesure et en quel sens les notions et les instruments d'al-Ṭūsī algébriste ont pu trouver leur rôle dans l'étude d'un problème somme toute traditionnel, et, qui plus est, de circonstance. Seule une réponse à cette question permettra à l'historien qui ne se contente pas d'une simple description de classer ce mémoire dans l'œuvre d'al-Ṭūsī. Mais avant d'esquisser cette réponse, résumons d'abord la solution d'al-Ṭūsī, en évitant, autant que possible, de nous écarter de son texte et de son style.

Soit $ABCD$ un carré tel que $AB = 10$, E un point arbitraire sur AB [voir figure 2].

On construit I tel que: $BI = 10 BE$. Joignons ID et de E menons $EF \parallel ID$, F sur BD . On a $BF = \frac{1}{10} AB$, d'où $BF = 1$.

Soit Y un point arbitraire sur BE , G et H tels que $YG = 54 BY$, $GH = 45 BY$. Joignons CF et menons $HJ \parallel GF$. On a $BJ = \frac{20}{11} BF$ ou $BJ = \frac{2}{11} BD$. Soit Θ arbitraire sur BD , Σ et Γ tels que:

$$\Theta\Sigma = 3024 J\Theta \quad \text{et} \quad \Gamma\Sigma = 725 J\Theta.$$

Un problème arithmético-géométrique de 'Sharaf al-Dīn al-Tūsī

ROSHDI RASHED*

L'œuvre strictement mathématique qui nous est parvenue de Sharaf al-Dīn al-Tūsī¹ se compose d'un *Traité sur les Equations* et de deux mémoires. Le *Traité*, nous l'avons montré ailleurs,² est l'un des ouvrages les plus importants dans l'histoire de l'algèbre classique: on pense y reconnaître les débuts de la géométrie algébrique.

Des deux mémoires, le premier, consacré à l'étude de l'asymptote à une branche d'une hyperbole équilatère, se révèle être une proposition de son précédent *Traité*. Nous considérons ailleurs³ sa situation dans un classement de l'œuvre du mathématicien.

Dans le deuxième mémoire, que nous présentons ici, al-Tūsī étudie un problème arithmético-géométrique. Oeuvre de circonstance – il s'agit d'une réponse à une question posée par le Directeur de la célèbre école de Bagdad: al-Nizāmiyya –, c'est là le dernier écrit mathématique d'al-Tūsī. D'Hamadān – l'ancienne Ecbatane – al-Tūsī expédiait à son correspondant la réponse à la question que voici:

Soit $ABCD$ un carré tel que $AB = 10$. On veut décomposer ce carré en quatre surfaces S_1, S_2, S_3, S_4 , telles que:

S_1 soit un rectangle dont un côté est porté par BD .

S_2, S_3, S_4 soient des trapèzes obtenus en joignant les deux autres sommets du rectangle aux points A et C .

Soient S_2 le trapèze de base AB , S_3 le trapèze de base DC et S_4 le trapèze de base AC . On veut aussi:

* C. N. R. S., Paris.

1. Sur l'œuvre de Sharaf al-Dīn al-Tūsī, voir nos études:

"Résolution des Equations numériques et Algèbre, Sharaf al-Dīn al-Tūsī. Viète", *Archive for History of Exact Sciences*, 13 (1974), 244-290.

"Recommencements de l'Algèbre aux XI^{ème} et XII^{ème} Siècles" dans J. E. Murdoch and E. D. Sylla, *The Cultural Context of Medieval Learning* (Dordrecht, Reidel, 1975), pp. 33-60.

"L'Extraction de la Racine $n^{\text{ième}}$ et l'Invention des Fractions Décimales (XI^{ème} - XII^{ème} Siècles)", *Archive for History of Exact Sciences*, 18 (1978), 191-243, et particulièrement les pages 208-213.

Voir également l'article "Tūsī, Sharaf al-Dīn", par A. Anbouba, in *Dictionary of Scientific Biography* (New York, Scribner's, 1970-1976).

2. Voir notre édition critique de ce *Traité* et sa traduction française, à paraître.

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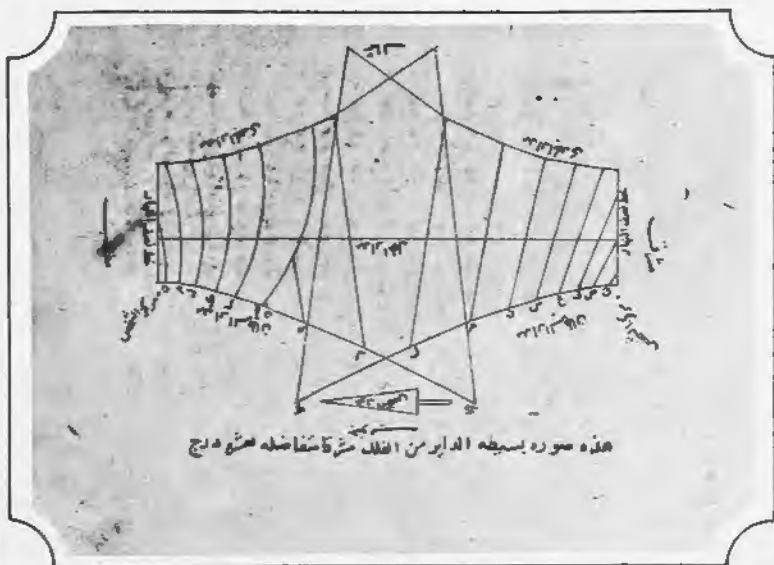
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